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USE OF HUMAN RESOURCES DATA IN WEAPON SYSTEM DESIGN: IDENTIFICA--ETC(U)

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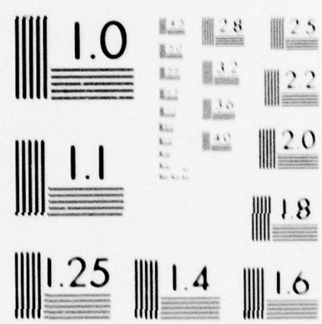

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AFHRL-TR-79-36

LEVEL II

AIR FORCE HUMAN RESOURCES LABORATORY

USE OF HUMAN RESOURCES DATA IN WEAPON SYSTEM DESIGN:

IDENTIFICATION OF DATA/DATA SYSTEMS AND RELATED TECHNOLOGY

By

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January 1980

Final Report

AIR FORCE SYSTEMS COMMAND
BROOKS AIR FORCE BASE, TEXAS 78235

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NOTICE

This final report was submitted by Clemson University, Clemson, South Carolina 29631, under contract F33615-78-C-0010, project 1124, with Advanced Systems Division, Air Force Human Resources Laboratory (AFSC), Wright-Patterson Air Force Base, Ohio 45433. Mr. Robert N. Deem (ASR) was the Contract Monitor for the Laboratory.

This technical report has been reviewed and is approved for publication.

GORDON A. ECKSTRAND, Technical Director
Advanced Systems Division

RONALD W. TERRY, Colonel, USAF
Commander

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The objective of this study is to establish criteria for development of a Unified Data Base of human resources information for use in system design. Existing data, data systems, and technology related to the use of human resource factors in weapon system design are identified and briefly discussed. Topics discussed include Maintenance Data Collection System, Maintenance Cost System, Human Resources Technology, Life Cycle Costing, Air Force Logistic Command Data Systems, Parametric Estimating Relationships, and data systems other than Air Force.

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PREFACE

This study was initiated by the Advanced Systems Division, Air Force Human Resources Laboratory, Wright-Patterson Air Force Base, Ohio under Project 1124, Human Resources in Aerospace System Development and Operations, Mr. Robert Deem, Task Scientist.

Appreciation is extended to Dr. William B. Askren of the Advanced Systems Division of AFHRL for his guidance and encouragement throughout this effort. Appreciation is also extended to the many individuals of Air Force Logistics Command and the Acquisitions Logistics Division at Wright-Patterson Air Force Base, Ohio, who supplied information in support of this study.

SUMMARY

BACKGROUND

It is well known that operational support costs represent a large percentage of the total life cycle cost of major weapon systems. The cost of human resources (manpower, personnel, training, etc.) required to provide operational ground support is one of the largest cost items associated with a weapon system. Operational support costs are, to a significant degree, determined by the operational/support concepts and performance/design characteristics of the weapon system hardware. Finally, most of the system concept and design decisions that significantly influence operational support costs are made during the early (conceptual and validation) program phases.

Department of Defense policy has increasingly emphasized the need for developing ways to reduce the operational support costs while maintaining adequate mission effectiveness of weapon systems. For the past 10 years or so, the Air Force Human Resources Laboratory (AFHRL) has been studying the relationships between human resources and complex hardware systems. As a result, AFHRL has developed a baseline of human resources technology. The objective of this technology is to enable a more meaningful integration of design/development activities (which create a demand for human resources) and the manpower, personnel and training activities which supply human resources. In other words, this technology attempts to make it possible for manpower, personnel, and training factors to have an influence on the hardware design/development process, as well as to be influenced by it.

Parallel with AFHRL efforts, numerous government and non-government organizations have developed technologies intended to assist in reducing operational support costs. These technologies include methods and models for logistics support analyses, cost estimations, and human resource requirement predictions related to reliability and maintainability factors. In recent years, much of this and the AFHRL technology has been implemented on various developmental programs. Such implementation, however, has been limited primarily to the detailed design and full-scale development phase.

For many years a large volume of historical data (human resource related) on current weapon systems has been collected and processed. Historically, the primary use of these data has been to improve the Operation and Support (O&S) capabilities of existing systems, thus the data systems have been tailored to satisfy these objectives.

PROBLEM

Regarding Human Resources Data (HRD), there is a need for a data system that will enable more effective utilization of the historical data base, data generating technology, and provide consistent and compatible information created for a specific weapon system under development. HRD refers to information that provides impact estimates, or otherwise describes ground support manpower requirements for O&S, as a function of alternative design concepts and approaches for system hardware and support concepts.

The data base specifically related to a new weapon system development program expands in time with the ever increasing definition and design of the system. The HRD elements in this weapon system data base should be compatible and consistent so as to effectively support the development of requirements and planning throughout the design/development process. In addition, the HRD elements in this data base should be consistent with data elements collected and processed during operational testing and the O&S phase; that is, the data that becomes part of the historical base. With greater consistency and compatibility between data elements in the developmental system and historical data bases, the greater the feasibility and utility of using historical data to reduce O&S costs of new weapon systems by incorporating these HRD into the early design process.

The data generating technology needs to be consistent and compatible with the developmental system data base. This technology would then be used to operate on the developmental system and/or historical data bases to support the early planning, design and development efforts of the new weapon system.

APPROACH

The primary objective of this study is to establish the criteria for future development of a data system, hereafter referred to as a Unified Data Base (UDB), of human resources information. The purpose of the UDB would be to enable more effective utilization of the historical data base, data generating technology, and the weapon system data base to provide compatible, consistent and useful HRD to influence early system design.

The study included four major tasks. The first was to identify existing data and data systems that relate to HRD and that are, or would be, useful and usable in the system design/development process. The second was to describe the weapon system design process with specific emphasis on integration of HRD to influence hardware design. The third task was to investigate the adequacy of existing HRD and to identify new and/or modified HRD for use in various phases of system design. The fourth and final task was to establish criteria for the development of a UDB. The first task is the subject of this report. The other three tasks will be discussed in subsequent reports.

CONCLUSIONS

There is an enormous volume of operational source data (historical data) that is directly or indirectly related to HRD. Operational Data Systems use this source data to create many by-products for logistics support planning, budgeting, and management. To a significant but lesser degree the source data and by-products are used by government and contractors in the weapon system acquisition process.

The body of human resources technology and associated literature is extensive. The collective work by AFHRL is clearly representative of the current state of technology in maintenance manpower modeling (MMM), human resources in design trades (HRDT), instructional system development (ISD) and job guide development (JGD). There are many organizations who have contributed to the strong technology base in cost and parametric estimating relationships, logistics support analysis (LSA), reliability (R), and maintainability (M). All of this technology and its application demonstrates that HRD can be used in the design of complex system hardware. When viewed in the light of a total weapon system program, however, there are severe limitations for applying this technology during the conceptual and early validation phases of a development program. The techniques for creating and using HRD to influence early system design are available, but the data bases required to effectively utilize the technology are inadequate. This is particularly true during the conceptual phase of a development program.

The relationships between human resource factors/data and complex system hardware are so pervasive that it is difficult to establish a clear line of demarcation for what is and is not HRD. Thus, for this study, an investigation of existing data that could be considered directly or indirectly related to HRD was undertaken. This included data necessary to support the AFHRL technologies, LSA, Integrated Logistics Data Files (ILDSs), cost models, and cost/parametric estimating relationships. In addition, it included an investigation of special purpose data bases, an existing data bases other than Air Force. The total body of existing data, data systems, and technology directly or indirectly related to HRD is substantial to say the least.

SECTION I

INTRODUCTION

The primary objective of this study is to establish criteria for development of a Unified Data Base (UDB) of human resource related information for utilization in the weapons system acquisition process to influence hardware design.

Data Base

This report presents the results of research efforts to identify existing human resources data (HRD), data systems, and related information that is or could be useful and usable to influence weapon system hardware design.

As used in this study, HRD refers to information, for use during design/development phases, that provides impact estimates or otherwise describes ground support human resource requirements in the Operation and Support (O&S) phase of a weapon systems life cycle. HRD are fundamentally those data which would assist in obtaining answers to the following questions about O&S ground support requirements as a function of alternative design concepts/approaches for system hardware and alternative support concepts:

How many people are needed?
What type of skills and skill levels are needed?
How available are the people needed?
How much will it cost to provide and maintain the needed skills?

In context with the above, HRD relates directly or indirectly to reliability (R), maintainability (M), personnel, training, technical data, manpower costs, test/support equipment, and human engineering information -- regardless of the source, form and content.

It must be emphasized, however, that there is no clear line of distinction as to what is and is not HRD. For example, an aircraft utilization rate has an impact on R&M, as does the number of landings when the R data are related to cycles rather than flight hours. Cost of ownership entails cost elements other than HRD, but those may have a direct relationship to the cost of human resources. The point is that a UDB may need to contain data elements that are not HRD, per se. For example, the UDB may need to contain Base Level Petroleum, Oil, and Lubricant (POL) Costs, Base Material Costs, Replenishment Spares Cost, and Support Equipment Costs. Thus, while HRD are technically considered to be the type of data defined in the preceding paragraph, it is not advisable to limit the scope of HRD for purposes of this study. For these reasons and because the relationships between human resource factors data and complex hardware systems are so pervasive, HRD will be considered in a broad context for this report.

Sections II, III and IV address HRD that may be referred to as source data available through operational data systems. These data and data systems provide historical information about existing weapon systems. Section V, VI and VII address technologies that utilize source data to generate HRD that applies new and developing weapon system. A brief description of each section follows.

Section II identifies and briefly discusses existing data and data systems directly related to HRD that are or could be useful and usable in the system design/development process. This section focuses on operational data and data systems, primarily the Air Force Maintenance Data Collection System (MDCS) and its derivatives. Because of the prevalent use of data collected in the field through MDCS on various equipments other than aerospace vehicles, this effort was limited to the major or primary data systems applicable to aircraft weapon systems. It should also be noted that many data systems interface with the primary source data systems and are routinely updated in the established processing cycle. No attempt has been made to identify all of the by-product data/data systems which may contain HRD related information. The data systems interfacing with the primary source data systems have been identified. These interfacing systems may or may not contain HRD per se, but they do contain data elements that are essential to planning and budgeting the ground support requirements for a new weapon system.

Section III discusses some important Air Force Logistics Command (AFLC) data base developments. The Integrated Logistics Data Files (ILDF) on four separate weapon systems are included in this section, along with other special purpose data bases.

Section IV identifies and briefly discusses major existing HRD sources other than Air Force. Selected Army and Navy data systems are included in this discussion.

Section V provides a summary of relevant literature in the area of human resources technology. The major focus is on exploratory and advanced development, and resultant reports addressing the creation and use of HRD to influence the design of complex system hardware.

Section VI provides an overview of existing life cycle cost (LCC) models and applications. Several of the most commonly used LCC models are discussed in some detail. In addition, a comparison of data elements and cost equations used in four cost models is presented.

SECTION II

IDENTIFICATION AND DISCUSSION OF EXISTING DATA AND DATA SYSTEMS

GENERAL

This section is divided into two major parts. The first part identifies ten (10) major sources of HRD. The governing directives and data processing used for each data source are identified. The second part discusses five of these ten major HRD sources in terms of inputs, outputs, interfaces, and information provided to users. Many references are made to data systems that are commonly known by the Data System Designator (DSD) and to reports generated from the various data systems commonly referred to by their Reports Control Symbol (RCS). Subsequent use of abbreviations that do not logically correspond to the associated description are the standard DSD or RCS.

IDENTIFICATION OF DATA/DATA SYSTEMS

Ten major sources of HRD are identified in this section:

1. Base Level Maintenance Data Collection System (MDCS)
2. Base Level Maintenance Cost System: MCS:H-129
3. Aerospace Vehicle Inventory Status: GO 33
4. Weapons System Effectiveness Programs and Models: KO 51
5. USAF Cost and Planning Factors: Air Force Regulation (AFR) 173-10
6. Logistics Support Analysis (LSA): Military Standard (MIL-STD) 1388-1
7. Unit Costs of Aircraft, Guided Missiles, and Engines: Technical Order (T.O.) 00-25-30
8. Standard Aircraft Characteristics: Air Force Guide (AFG) 2
9. Group Weight Statements: AN-9103-D and Applicable -2 Technical Orders
10. Systems Effectiveness Data System (SEDS)

BASE LEVEL MAINTENANCE DATA COLLECTION SYSTEM (MDCS)

Data Source and Governing Directives -

The primary source of useful and usable HRD for design engineers is the MDCS. The MDCS is governed by Air Force Manual (AFM) 66-1. This manual contains the implementing instructions for the MDCS and assignment of specific responsibilities within the maintenance complex for the collection, handling, processing and analysis of the data collected at base level. Instructions for key punching and processing the data collected on the base level B-3500 computer are contained in AFM 66-267. The basic source document for the MDCS is the Air Force Technical Order (AFTO) Form 349. In addition to the base level reports generated from the data collected, the detailed corrective on-equipment and off-equipment (shop) records, plus the Scheduled and Special Inspection (look) Support General records, are transmitted to AFLC via the Log-MMO(AR)7142 reports (formerly the I-Log-K97 reports).

Data Processing -

The data reported to AFLC from base level is centrally processed at Wright-Patterson AFB, Ohio. After the initial "Edit/Error" processing, the edited data are input to the DO 56 Product Performance Data System. The DO 56 generates experience data by type equipment and deficiency analysis for the purpose of logistically evaluating item performance and system performance.

AFLC Regulation 66-15 establishes requirements for maintenance of the data system and the procedures governing the utilization and analysis of deficiency data reported on Air Force systems and equipment. The automatic data processing systems and procedures for the DO 56 Product Performance System are contained in AFLC Manual 171-45.

BASE LEVEL MAINTENANCE COST SYSTEM (MCS:H-129)

Data Source and Governing Directives -

The base level maintenance cost system (MCS:H-129) uses data from the following level sources:

MDCS

Standard Base Supply System

Accounting and Finance

Engine Manager

Maintenance Exception Time Accounting System

Data from the MDCS, plus additional data collected using the same source document, are used to develop maintenance manpower cost data by type equipment, program element, workload breakdown structure, and work accomplishment code. Data from all of the above sources are used to develop overall base level maintenance cost data. The standard procedures related to all aspects of the base level cost system performed on the B-3500 computer are covered in AFM 177-380.

Data Processing -

Outputs from the base level MCS:H-129 are transmitted via the HAF-ACF (M&Q) 7403 reports to the Major Command. The Major Command processes and accumulates cost data by type equipment command wide. The Major Command then generates the Command Maintenance Manpower Information System (CAMMIS) data for reporting to Air Force/PRMD. The Major Command maintenance cost data are also reported to Air Force for input to the Operations and Support Cost Report (OSCR) by weapons system. Depot maintenance cost data are generated by AFLC through the HO 36 Data System for input to Air Force OSCR.

AEROSPACE VEHICLE INVENTORY, STATUS, AND UTILIZATION REPORTING: GO 33

Data Source and Governing Directives -

The standard Aerospace Vehicle Inventory, Status and Utilization Reporting System (AVISURS) is governed by AFR 65-110. This reporting system interfaces with the AFLC DO 36 Data System and provides information about aerospace vehicles in the Air Force inventory. The information includes vehicle assignment, possession, status, flying hours, number of landings, sorties, total airframe hours, and total engine hours.

Data Processing -

The base level reports are transmitted via the HAF-LGY(M)7502 reports to the Major Command. The Major Command processes the data received from base level as specified in AFM 65-663. The base level AVISURS data processing procedures and output distribution is outlined in AFM 171-260.

WEAPONS SYSTEMS EFFECTIVENESS PROGRAM AND MODELS: KO 51

Overall Purpose of Model -

The KO 51 is a system effectiveness/availability ranking model designed to provide the following capabilities:

1. Statistical evaluation of weapon system effectiveness
2. Identification of specific systems or equipment effecting force degradation
3. Analysis and evaluation of historic utilization, downtime, and maintenance man-hour data on terminated or "out-of-commission" aircraft
4. Correlation of aircraft downtime and maintenance man-hours.

Problem Areas Isolated by Model

Weapon system effectiveness is often based on cost, capability, and performance. In today's austere environment, management indicator programs are essential for effective allocation, or reallocation, of limited resources to improve and maintain system effectiveness. The following models were designed to isolate possible problem areas.

1. Logistic Support Cost (LSC) ranking (KO 51, Part 2): Weapons Systems support costs identified to work unit code (WUC). Equipment/components are computed and ranked to identify disproportionate resource consumers. Cost areas considered are field maintenance man hours, packaging and transportation, specialized repair activity man-hours, materials, overhead and condemnation replacements.

2. Availability ranking (KO 51, Part 3):
   Output from this model is in terms of degradation to Weapon System availability. Computed degradation factors are ranked to reveal the equipment/components or aircraft which are the highest contributors to non-availability and reduced performance of the force.

3. Flight Safety Prediction Technique Model (GO 95):
   This model estimates and ranks the material failure hazard rate of a weapon system by WUC (excluding primary structure). The criticality number calculated is an estimate of the probability of exposure of the system to a hazardous condition (hazard rate) due to malfunction of a specific WUC item during an average sortie.

4. Summarized results of investigations of indicated problems are contained in Part IV, where each individual summary is assigned an item number. The reference report column of the model output reflects an item number and report identifier (the month and year in which the item number last appeared) for each WUC for which a summary analysis was prepared.

5. Changes effective 1 October, 1977:
   Mission Capability (MICAP) reporting has replaced the Maintenance and Supply status reporting in AFR 65-110 data. Not Mission Capable (NMC) or Partial Mission Capable (PMC) status is now used to describe vehicle status. NMC and PMC status is determined by the Mission Essential Subsystem List (MESL). NMC and PMC are not directly related to the aircraft flyable status. These values are not equivalent to the previously used terms (Not Operationally Ready, Grounded, or Flyable) and therefore are not comparable. Due to

an error in data input from GO 33, hours possessed are excessive for the 4th quarter 1977. Errors of this nature could affect the accuracy of system effectiveness, Fully Mission Capable (FMC), and alert availability reporting.

USAF COST AND PLANNING FACTORS (AFR 173-10)

This regulation contains USAF cost and planning factors which can be used for estimating and analyzing resource requirements and costs for active Air Force, Air National Guard, and Air Force Reserve Forces in a peace time environment. Where appropriate, the factors can be traced to the conventional budget structure and the five year defense program (FYDP). Chapter 2 of the regulation provides explanatory material with respect to each of the cost and planning factor tables. This narrative, presented sequentially by table, is concerned with factor development objective, derivation, use limitations, and where appropriate, examples of use. USAF Cost and Planning Factors tables are included as attachments. Table 51 of the regulation contains the factors used in the Air Force Cost Analysis Cost Estimating (CACE) Model.

LOGISTICS SUPPORT ANALYSIS (MIL-STD-1388-1)

This standard establishes criteria governing performance of a LSA, integral to the engineering process, to define support system requirements and inject support criteria into system/equipment design and development. This standard applies to any system/equipment acquisition program, or major modification program, from the early program initiation (conceptual) phase through the deployment phase. It is intended that this standard be used by both contractor and government activities implementing LSA. The Logistics Support Analysis Records (LSARs) prescribed by this standard provide the mechanism for generating invaluable human resources data. This is particularly true if the Air Force will standardize basic data elements and require LSARs on all acquisition programs. LSARs appear to have the potential for satisfying most of the objectives of the five Air Force Human Resources Laboratory (AFHRL) technologies -- namely; Maintenance Manpower Modeling (MMM), Instructional System Development (ISD), Job Guide Development (JGD), System Ownership Costing (SOC), and Human Resources in Design Trade-off (HRDT).

UNIT COSTS OF AIRCRAFT, GUIDED MISSILES, AND ENGINES (T.O.00-25-30)

Technical Order 00-25-30, Unit Costs of Aircraft, Guided Missiles and Engines, dated 1 September 1978 reflects many major revisions to the information contained in previous editions of this document.

Table I of T.O. 00-25-30 excludes all Research and Development (R&D) and Class V Modification (MOD) costs. Table II of this T.O. provides R&D and Class V Mod costs where possible. The R&D costs shown are cumulative through FY77 distributed over the number of aircraft procured to reflect unit R&D costs. The term "specific R&D" is applicable to the specific weapon system series, whereas "prorated R&D" is applicable to several or all series of a weapon system. R&D includes support equipment (SE) and other support R&D. Table III of this T.O. also reflects Class V MOD costs. Class MODS are defined as changes in the physical configuration or or in the functional characteristics of a system or equipment. Class V MOD costs identified as prorated pertain to several or all series within a weapon system. Unfortunately, for cargo type aircraft, Table III reflects "specific R&D" costs for the C-5A only and "prorated R&D" costs for the C-130A, DC-130A, DC130B, and the C130D only. For the purpose of developing parametric estimating relationships for cargo type aircraft, this source of cost data is inadequate.

STANDARD AIRCRAFT CHARACTERISTICS (AIR FORCE GUIDE 2)

The AFG-2 contains standardized mission profiles which contain comparable design or performance characteristics for USAF aircraft. These characteristics may be used to develop estimating relationships for O&M costs when used as independent parameters and related to historical data.

GROUP WEIGHT STATEMENTS (AN-9103-D and Applicable Technical Orders)

The group weight statements and the applicable technical manual maintenance procedures (-2T.O.s) provide another source of data used in deriving parametric estimates where parameters such as aircraft weight, systems weight, fuel weight, number of hydraulic pumps, number of control surfaces and number of Line Replacement Units (LRUs) are used as the independent parameters.

SYSTEMS EFFECTIVENESS DATA SYSTEM (SEDS)

The SEDS collects data generated during Category II verification and demonstration testing. The source document for this data system is Air Force Systems Command (AFSC) Form 258. This form is designed to capture all of the same data elements used in the AFM 66-1 MDCS. In addition, the form is used to capture supplemental failure data for reliability, and information relative to the adequacy of support equipment and technical data. Finally, the form is used to report up to three Air Force Specialty Codes for troubleshooting and repair functions.

DISCUSSION OF DATA/DATA SYSTEMS

Five of the major HRD sources identified above are discussed in greater detail below. These five are the Maintenance Data Collection System, Maintenance Cost System, USAF Cost and Planning Factors, Logistics Support Analysis, and Systems Effectiveness Data System.

MAINTENANCE DATA COLLECTION SYSTEM (MDCS)

Recording and Reporting -

The recording and reporting instructions for the MDCS are contained in the 00-20 series technical orders. The source document used to collect the data is the AFTO Form 349. These forms are originated by the individual (s) accomplishing the work. Figure 1 illustrates the data elements that can be reported. The specific data elements reported for a given transaction are dependent on the type of maintenance that was performed. The following technical orders relate to the types of maintenance and/or equipment to which the recording instructions relate:

1. 00-20-2-2 On-Equipment Maintenance Documentation for

MAINTENANCE DATA COLLECTION RECORD

OMB NO. 21-R0227

1. JOB CONTROL NO.	2. WORKCENTER	3. I.D. NO./SERIAL NO.	4. MDS	5. EQ/CL	6. TIME	7. PRI	8. SORTIE NO.	9. LOCATION
10. ENG. TIME	11. ENGINE I.D.	12. INST ENG TIME	13. INST. ENG. I.D.	14.	15.	16.	17. TIME SPC REQ	18. JOB STD
19. FSC	20. PART NUMBER	21. SER. NO./OPER. TIME	22. TAG NO.	23. INST. ITEM PART NO.	24. SERIAL NUMBER	25. OPER. TIME		

ACT. LINE	A TYPE MAINT	B COMP POS	C WORK UNIT CODE	D ACTION TAKEN	E WHEN DISC	F HOW MAL	G UNITS	H START HOUR	I STOP DAY	I STOP HOUR	J CREW SIZE	K CAT LAB	L CMD ACT ID	M SCH CODE	N EMPLOYEE NUMBER
1															
2															
3															
4															
5															

26. DISCREPANCY

27. CORRECTIVE ACTION

28. RECORDS ACTION

AFTO FORM MAY 75 349 PREVIOUS EDITION IS OBSOLETE.

Figure 1. AFTO FORM 349 - maintenance data collection record

Aircraft; Air Launched Missiles; Ground Launched Missiles (except ICBM); Drones; and Related Training Equipment

2.	00-20-2-4	Maintenance Documentation for In-Shop Engine Maintenance
3.	00-20-2-5	On-Equipment Maintenance Documentation for Intercontinental Ballistic Missiles (ICBM)
4.	00-20-2-6	On-Equipment Maintenance Documentation Nuclear Ordinance Commodity Management Material, Re-entry Vehicles and Re-entry Systems, and Related Test and Handling Equipment (Excluding Nuclear Weapons)
5.	00-20-2-7	On-Equipment Maintenance for SE, Trainers and Simulators
6.	00-20-2-8	On-Equipment Maintenance Documentation for Ground Communications-Electronics-Meteorological (CEM) Equipment.
7.	00-20-2-10	Off-Equipment Maintenance Documentation for Shop Work, Conventional Munitions, and Precision Measuring Equipment (PME)
8.	00-20-2-13	AFLC Depot and Contractor In-Shop Maintenance Documentation, Peculiar Engine Documentation, and Contractor Data Submission
9.	00-20-3	Maintenance Processing of Repairable Property and Repair Cycle Asset Control System
10.	00-20-4	Configuration Management Systems
11.	00-20-5	Aircraft, Drone, and Air Launched Missile Inspections, Flight Reports, and Supporting Maintenance Documents

12. 00-20-6 Inspection System, Documentation, and Status Reporting for Ground Launched Missiles and their Trainers, SE and Ground CEM Equipment

13. 00-20-7 Inspection System, Documentation, and Status Reporting for Support and Training Equipment (Excluding Ground Launched Missile Equipment)

14. 00-20-8 Inspection System, Documentation, and Reporting for Ground CEM Equipment Used in Direct Support of Ground Launched Missiles

15. 00-20-9 Forecasting Replacement Requirements for Selected Calendar Time Change Items

These technical orders implement the Air Force policies of: AFR 66-14, Equipment Maintenance Policies, Objectives, and Responsibilities; AFM 66-1, Maintenance Management; and AFR 66-5, Production Oriented Maintenance Organization (POMO).

Base Level Processing -

The information recorded by the Specialist/Technicians performing the maintenance is processed through the activity that has been assigned the key punch responsibility. This may be within the maintenance complex or in data processing. The specific instructions for the operation and maintenance of the MDCS for those bases having the B-3500 computer are contained in AFM 66-267, and are used in conjunction with AFM 66-1 and T.O.00-20-2. The detail 66-1 MDCS record formats for the various type equipment/maintenance actions are presented in Figure 2. These records are automatically generated during the routine daily processing of the MDCS data at base level. These records are transmitted via AUTODIN or by mail, in the form of magnetic tapes and punched card decks, to AFLC for processing into the DO 56 Product Performance System. While these formats are identified to the DO 56E data system, they correspond to the LOG-MMO(AR)142 record formats in Columns 1 through 80. The DO 56E data is a record image output to tape for distribution to authorized

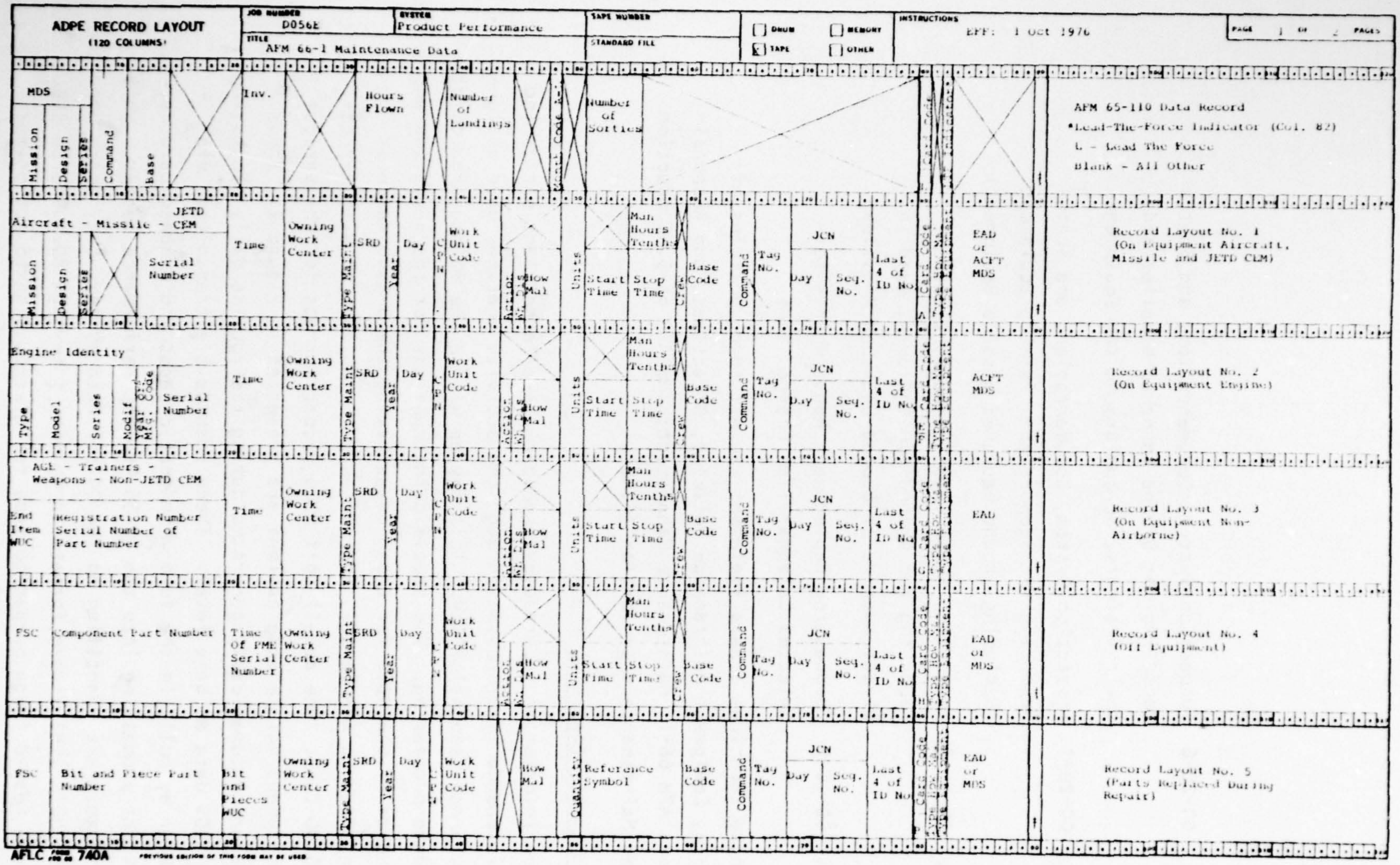

Figure 2. Automatic data processing record layout

ADPE RECORD LAYOUT (120 COLUMNS)	JOB NUMBER: D056E	SYSTEM: Product Performance	TAPE NUMBER	☐ DRUM ☐ MEMORY ☒ TAPE ☐ OTHER	INSTRUCTIONS	PAGE 2 OF PAGES
	TITLE: AFM 66-1 Maintenance Data		STANDARD FILE			

Fields	Record Layout
FSC; Component Part; Owning Work Center; Type Maint; SRD; Year; Day; CPN; Work Unit Code; Action; HW Dis; How Mal; Item Serial Number; Remove; Base Code; Command; Tag No.; JCN (Day, Seq. No.); Last 4 of ID No; Card Code; Type How Mal; Type Equipment; EAD or MDS	Record Layout No. 6 (Removal of Serialized Components)
Component Part Number; Replace Item Time; Owning Work Center; Type Maint; SRD; Year; Day; CPN; Work Unit Code; Action; Item Serial Number; Install; Base Code; Command; Tag No.; JCN (Day, Seq. No.); Last 4 of ID No; Card Code; Type Equipment; EAD or MDS	Record Layout No. 7 (Installation of Serialized Components)
Aircraft Identity (Mission, Design, Series, Serial Number); Engine Time; Owning Work Center; Type Maint; SRD; Year; Day; CPN; Engine Identity (Type, Model, Series, Modif, Year or Mfg Code, Serial Number); Base Code; Command; Tag No.; JCN (Day, Seq. No.); Last 4 of ID No; Card Code; Type Equipment; ACFT MDS	Record Layout No. 8 (Removal/Installation of Aircraft Engines)
Aircraft - Missile - CEM JETD (Mission, Design, Series, Serial Number); Time; Owning Work Center; Type Maint; SRD; Year; Day; CPN; TCTO Data Code; How Mal; Units; Start Time; Stop Time; Man Hours Tenths; Crew; Base Code; Command; Tag No.; JCN (Day, Seq. No.); Last 4 of ID No; Card Code; Type Equipment; EAD or MDS	Record Layout No. 9 (Aircraft, Missile, and JETD CEM TCTO Data)
Engine Identity (Type, Model, Series, Modif, Year or Mfg Code, Serial Number); Time; Owning Work Center; Type Maint; SRD; Year; Day; CPN; TCTO Data Code; How Mal; Units; Start Time; Stop Time; Man Hours Tenths; Crew; Base Code; Command; Tag No.; JCN (Day, Seq. No.); Last 4 of ID No; Card Code; Type Equipment; ACFT MDS	Record Layout No. 10 (Engine TCTO Data)
AGE-Trainers-Weapons-CEM NON-JETD (End Item WUC; Registration Number Serial Number or Part Number); Time; Owning Work Center; Type Maint; SRD; Year; Day; CPN; TCTO Data Code; How Mal; Units; Start Time; Stop Time; Man Hours Tenths; Crew; Base Code; Command; Tag No.; JCN (Day, Seq. No.); Last 4 of ID No; Card Code; Type Equipment; EAD	Record Layout No. 11 (Non-Airborne TCTO Data)
FSC; Component Part Number; Time; Owning Work Center; Type Maint; SRD; Year; Day; CPN; TCTO Data Code; How Mal; Units; Start Time; Stop Time; Man Hours Tenths; Crew; Base Code; Command; Item Serial Number; Last 4 of ID No.; Card Code; Type Equipment; EAD	Record Layout No. 12 (Off Equipment TCTO Data)

AFLC FORM FEB 68 740A PREVIOUS EDITION OF THIS FORM MAY BE USED

Figure 2. (Concluded)

contractors. The data contained in Columns 81 through 90 of the tape record layout are for AFLC Processing Control purposes and may be used by the contractors as an aid in their processing of the DO 56E data.

Abbreviations used in Figure 2 that do not appear elsewhere in the report are:

AGE	-	Support Equipment
EAD	-	End Article Designator
FSC	-	Federal Stock Code
How Mal	-	How Malfunctioned
I.D. No.	-	Identification Number
INV	-	Inventory
JCN	-	Job Control Number
JETD	-	Joint Electronics Type Designator
LTF	-	Lead the Force
MDS	-	Mission Design Series
Modif	-	Modification
Seg. No.	-	Sequence Number
SRD	-	Standard Reporting Designator
TCTD	-	Time Complicance Technical Order
Wh Dis	-	When Discovered
Yr or Mfg	-	Year or Manufacturer

<u>AFLC Processing</u> -

The detailed AFM 66-1 data records transmitted to AFLC are processed by the AFLC DO 56 data system. The initial processing is the DO 56A Error Edit and Analysis Routine. During this process, three (3) input data systems are interfaced and thirteen (13) output data systems are interfaced. An overview data flow process and interfacing chart is presented in Figures 3 and 4. This reflects the general data flow process from the point of origin (base, depot, or contractor) through the DO 56 Product Performance Analysis Process. Tables 1 and 2 identify the output products and data element contents of the reports identified by RCS and Product Control Number (PCN). The policies, requirements for data systems

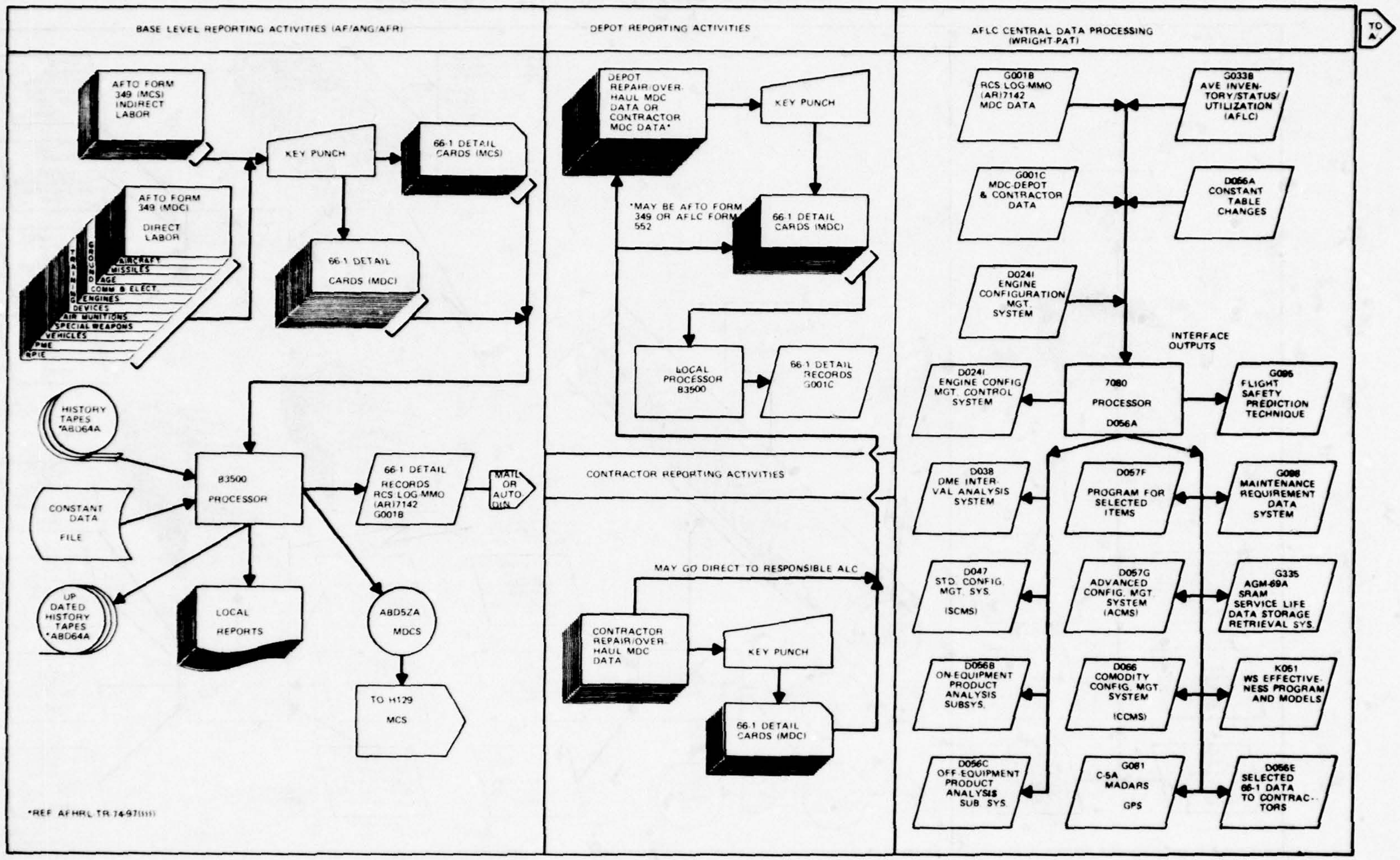

Figure 3. AFLC DO 56 data system - base level to AFLC

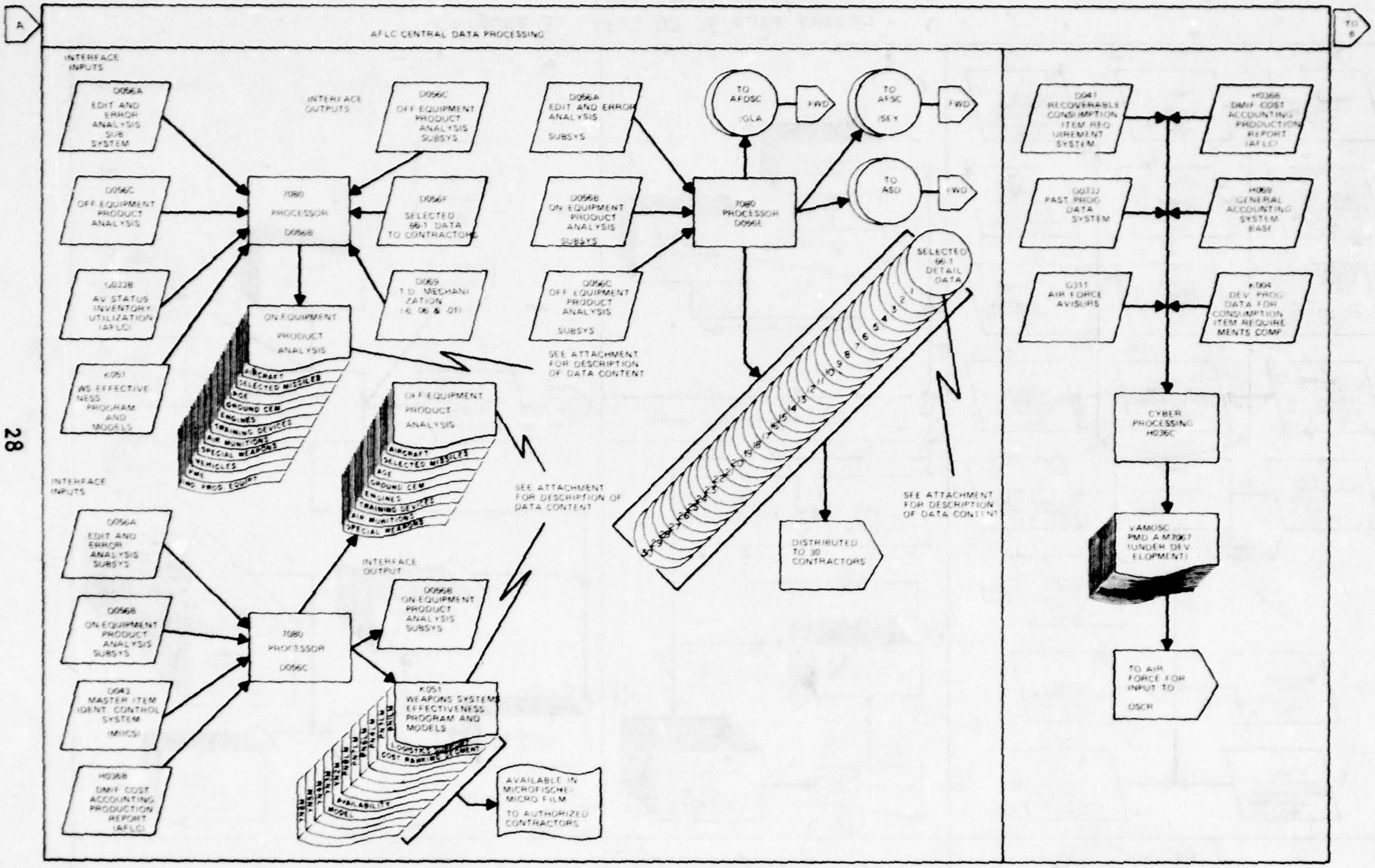

Figure 4. AFLC DO 56 data system - AFLC data processing

TABLE I. DO 56 ON-EQUIPMENT REPORTS

DO56 (SERIES) REPORTS — "ON-EQUIPMENT" REPORTING

REPORTS IDENTIFY EQUIPMENT BY MISSION/DESIGN/SERIES//TYPE/MODEL/SERIES

RCS MMO(AR)-	7166	7168	7169	7170	7171	7174	7175	7179	7180	7183	7184	7185
PCN DO56B-	5002	5504	5505	5006	5007	5011	5012	5016	5017	5522	5023	5025
REPORT FREQUENCY	MO	DMD	DMD/ MO	MO	MO	DMD/ ANLY	DMD/ ANLY	QTRY	QTRY	QTRY	QTRY	QTRY
CONTENTS		#3										
ABORTS	X			X	X#1,2							
ACCIDENTS	X											
ACTION TAKEN		X	X		X		X			X	X	
ACTIONS TOTAL			X	X								
ACTIONS TRUE						X						
ADJUST(SUMMARY)*			X									
BASE/COMMAND ID		X	X		X				X**		X	
CATEGORY INDICATOR	X	X	X	X						X	X	
CLEAN/TEST/CORROSION*			X									
CONDEMNED*		X	X	X								
CORROSION, M/H COST								X**	X**			
CORROSION UNITS								X**	X**			
EUMR'*	X											
FSC*		X	X		X							
HIGH-10 WUC'*												
HIGH-25 WUC'*	X							X**				
HIGH-25 WUC CORR. M/H	X											
HOW-MALFUNCTION		X			X		X				X	
INCIDENTS	X											
INVENTORY				X								
LANDINGS, AIRCRAFT	X											
LIMITS, ACTION				X							X	
MALFUNCTIONS, FAILURE			X	X						X	X	
MALFUNCTIONS, OTHER			X	X								
MALFUNCTIONS, TYPE NR.		X	X									
MANHOURS, ON-EQUIPMENT	X		X	X				X**	X**			
SCHEDULED				X				X**				X
UNSCHEDULED				X				X**				X
TRUE-ACTION						X						
HOW-MAL							X					
MANHOURS, OFF-EQUIPMENT	X	X	X	X				X**				
MANHOURS PER FLYING HR.												X
MANHOURS, TCTO												X
MANUFACTURER CODE*		X	X									
MMC(CODE)*		X	X		X							
MTBF	X			X						X	X	
MTBM				X								
MTBTMA						X						
NIIN*		X	X									
NRTS*		X	X	X								
OPERATING TIME	X			X								X
PART NUMBER*		X	X		X							
PARTS REPLACED*		X	X									
QUANTITY PER APPLICATION	X			X				X**			X	
REPAIRED*		X	X	X								
REPLACEMENT INTERVAL							X					
SERVICEABLE*		X	X			X						
SERIAL NUMBER					X							
SORTIES(AVG. LENGTH, MSBF)										X		
SUMMARY, SYSTEM/SUB SYSTEM				X		X			X**			X
TIME CHANGE REMOVALS			X				X					
UNITS*		X	X									
WHEN-DISCOVERED					X							
WORK UNIT CODE	X	X	X	X	X	X	X	X**	X**	X	X	
ENGINE DATA	X											
SPECIAL INVENTORY				X								
-6 INSPECTION REQUIREMENT						X						
MALFUNCTIONS TOTAL			X	X								

LEGEND:
*DENOTES SHOP ACTION
**CORROSION DATA ONLY
#1 BEFORE-FLIGHT
#2 IN-FLIGHT
#3 THE 5504 REPORT CONTAINS SHOP DATA ONLY

ABBREVIATIONS:
MO - MONTHLY
DMD - DEMAND
QTRY - QUARTERLY
ANLY - ANNUALLY
EUMR - EMERGENCY UNSATISFACTORY MATERIAL REPORT
FSC - FEDERAL STOCK CLASS
MMC -
MTBF - MEAN TIME BETWEEN FAILURE
MTBM - MEAN TIME BETWEEN MAINTENANCE
MTBTMA - MEAN TIME BETWEEN TRUE MAINTENANCE ACTION
NIIN - NATIONAL ITEM IDENTIFICATION NUMBER
NRTS - NOT REPARABLE THIS STATION

TABLE 2. DO 56 OFF-EQUIPMENT REPORTS

D056 (SERIES) REPORTS — OFF-EQUIPMENT REPORTING

RCS MMO(AR)	7188	7189	7190	7191	7192	7193	7194	7195	7196	7197	7198	7199	71100	71101	71102	71103	71104	71105	71106	71107	71108	71109	71110
PCN D056C	4402	4403	4404	5605	4407	5009	5010	4417	5718	5719	5920	5021	5022	5024	3226	5027	5028	5929	5930	3231	3232	5033	5034
REPORT FREQUENCY	MO DMD	MO DMD	MO DMD	DMD ONLY	DMD	QTRY	QTRY	MO	MO	MO	SIX MO	SIX MO	MO	MO	MO	QTRY	^TRY	SIX MO	SIX MO	MO	MO	SIX MO	SIX MO
CONTENTS																							
ABORTS		X																					
ACTION TAKEN		X			X		X				X	X						X			X		
ACTIONS TOTAL					X									X		X							
ACTIONS TRUE	X	X																					
ALC	X	X	X	X	X			X	X	X	X	X	X	X	X			X	X	X		X	X
BASE/COMMAND ID		X			X	X	X			X	X		X	X	X	X	X			X	X		
CONDEMNED	X					X	X	X						X									
EAD		X	X														X					X	
EQUIPMENT CLASS CODE/MDS				X								X	X	X	X	X*				X			
ERRC	X							X				X		X								X	X
FSC	X	X	X	X	X			X				X		X	X		X			X	X		X
HOW MALFUNCTION CODE		X**	X**	X**	X**						X*	X**											
INTERVAL CHANGE																			X				
LIMITS, CONTROL	X																						
LIMITS COMPUTED	X																						
MANUFACTURE CODE																							X
MANHOURS TOTAL		X				X				X	X	X		X		X							
MATERIAL MANAGEMENT CODE	X	X	X	X	X			X				X		X									X
NIIN	X	X	X					X				X		X								X	X
NRTS	X					X	X	X				X		X		X	X#						
PART NUMBER	X**	X	X**	X	X			X	X	X		X**		X	X		X		X**	X	X	X**	X**
PART NO. "BIT & PIECE"			X																				
REPAIRED	X		X	X		X	X	X								X							
REPLACED			X																				
TECHNICIAN RESPONSIBLE	X	X						X														X	
SERVICEABLE	X													X									
SRA "MOD" QUANTITY			X																				
SRA "MRS" QUANTITY			X																				
UNIT PRICE												X											X
UNITS		X(1)				X	X			X	X	X			X	X	X	X	X	X	X		
WHEN DISCOVERED CODE		X			X																X		
WORK UNIT CODE				X	X				X	X	X	X			X		X	X	X	X	X	X	
WORK CENTER(OWNING)																					X		

* Denotes shop action
** Corrosion data only

maintenance, and procedures governing the utilization and analysis of deficiency analysis data reported on Air Force Systems and Equipment are covered in AFLC regulation 66-15 as amended. A brief description, frequency, and criteria used to produce each PCN identified is included in this regulation. Procedures and sample output product formats for the operation of the Product Performance System (DO 56) are contained in AFLC Manual 171-45.

By-Products of DO 56 System -

As a by-product of the DO 56 Product Performance System, the KO 51 (Weapons Systems Effectiveness Program and Models) is exercised at the same time as the DO 56C Off-Equipment Product Analysis Subsystem is exercised. The output products and data elements by identified RCS and PCN are displayed in Table 3. These reports are available in microfiche to authorized contractors.

Maintenance Data to Contractors -

The DO 56E (AFM 66-1 Maintenance Data to Contractors) processes the on-equipment and off-equipment tapes from DO 56A, and segregates product information for approved contractors. The output, in tape form, is record image of the 66-1 detail records that were passed by error edit subsystem to the DO 56A04B0 and DO 56A04A0 data tapes. The data tapes also contain AFR 65-110 flying hour information corresponding to the equipment and time period to which the maintenance data relates. This information is essential to the contractor in order to derive reliability rates and Maintenance Man-hour Per Flying Hour (MMH/FH) information from the data contained on the tapes. The various contractors who receive the data have developed their own data processing and data bases to meet their requirements in performing R&M studies, and where appropriate, LSA and trade studies.

Many contractors have used DO 56 data in independent research and development efforts (IR&D), some of which have great potential benefits to the Air Force as well as the aerospace industry. Some contractors

TABLE 3. KO 51 REPORTS

KO 51(SERIES) REPORTS - LOGISTIC SUPPORT COST RANKING SEGMENT

RCS LOG MMO(Q)	7213(1)	7213(2)	7213(3)	7213(4)	7215	7213(6)	7213(7)
PCN KO51	PN1L/M	PN3L/M	PN4L/M	PN6L/M	PN7L/M	PN8./M	PN4/M
REPORT FREQUENCY							
CONTENTS							
ABORTS-BFA-IFA					X		
ACCESSIBILITY CORRECTOR							
CONTROL						X	
CATEGORY INDICATOR	X	X				X	
CODING EXEMPT	X	X				X	
CONDEMNED BY NSN-							
OFF-EQUIPMENT					X		
DATE PROCESSED	X	X	X	X	X	X	
ERRC CODE						X	
EXPENDED BY NSN					X		
FH(FORCE)							
CURR,1ST,2ND,3RD QTR		X					
INVENTORY ENGINES(FORCE)							
CURR,1ST,2ND,3RD QTR		X					
INVENTORY(FORCE)							
CURR,1ST,2ND,3RD		X					
LANDINGS(FORCE)		X					
LSC NSN by WUC				X			
LSC-TOTAL NSN				X			
LSC-By WUC				X			
By WUC CURR,							
LSC-1ST,2ND,3RD QTR							
LSC-CONDEMNATION COST			X				
By WUC-CURR QTR							
LSC-FIELD MAINT. COST-			X				
By WUC-CURR QTR							
LSC-SPEC REPR COST-			X				
By WUC-CURR QTR							
LSC-PACK & SHIP-			X				
By WUC-CURR QTR							
LSC-TOTAL COST-			X				
CURR,1ST,2ND,3RD QTR							
LSC-TOTAL SYSTEM-		X					
2ND,3RD, QTR							
LSC-(FORCE) CURR. 1ST.		X					
MANHOUR, AVERAGE			X		X		
MDSN by WUC	X	X		X		X	
MDSN by NSN				X	X		
OFF-EQUIPMENT							
NO-DEFECT NNSN-					X		
OFF-EQUIPMENT							
NRTS by NSN-					X		
NSN				X	X	X	
NUMBER TO SHOP				X			
1ST,2ND,3RD QTR							
OR HOURS-ENG-CURR.		X					
OTHER ACTIONS BY NSN					X		
LSC							
PERCENT NSN LSC TO WUC				X			
OWNED							
PERCENT OF DEPOT COND-						X	
By WUC							
PERCENT OF SYSTEM-	X			X			
WUC							
PERCENT by SYSTEM-		X					
PRIME ALC	X	X	X	X	X	X	
Q/A						X	
1ST,2ND,3RD,QTR							
RANK BY LSC/WUC CURR.	X	X					
ON-EQUIPMENT							
REPAIRED BY NSN-					X		
SPECIAL SPAE	X	X				X	
SPECIAL INVENTORY	X	X					
USE FACTOR							
SRA-REPAIR COST OR-						X	
CURRENT QUARTER							
TCTO(FORCE) MMH COST		X					
ON-EQUIPMENT							
TO SHOP BY NSN-					X		
TOTAL NUMBER OF WUC's		X					
REPORTED THIS QTR							
TOTAL NUMBER OF WUC's		X					
UNITS					X		
UNIT PRICE & NSN		X				X	
WEAPONS SYSTEM	X		X	X	X	X	
INVENTORY							
WEIGHT OF SPECIAL-	X	X				X	
WUC			X	X	X	X	
WUC-OLD						X	

LOGISTIC SUPPORT COST MODELS AND AVAILABILITY MODEL

RCS LOG-MMO(Q)	7216(1)	7216(2)	7216(3)	7216(5)	7216(6)	*7372	LOG(MMO) 7370	7371	LOG[illegible](Q)
PCN KO51	TN6M	TN4M	TN5M	TN3M	TN2M	YR1L	YR1L	YR2L	
ABORTS (BF,IF)	X	X							
ATTEMPTED SORTIES	X								
CATEGORY INDICATOR		X		X	X				
DATE PROCESSED	X	X	X	X	X				
DEGRADATION									
RANK-CURR,1ST,2ND,3RD QTR			X	X	X				
PERCENT-CURR,1ST,2ND,3RD QTR			X	X	X				
FLYING HOURS	X								
HOURS POSSESSED-BASE	X								
HOURS POSSESSED-DEPOT	X								
INVENTORY TERMINATION	X								
MMH-SCHEDULED	X								
MMH-UNSCHEDULED	X	X							
NMCM HOURS-UNSCHEDULED		X							
NMCS HOURS-UNSCHEDULED		X							
NMCS HOURS									
NORM HOURS-SCHEDULED	X	X							
NORM HOURS-UNSCHEDULED	X	X							
NORS HOURS-BASE	X								
NORS HOURS-DEPOT	X								
PRIME ALC	X								
QPA		X							
SORTIES	X								
SPECIAL INVENTORY		X							
TAIL NUMBER	X		X						
WEAPON SYSTEM	X	X	X	X	X				
WUC		X		X**	X**				
WUC-OLD		X							

*INCLUDES NSN

**INCLUDES 1 DIGIT WUC SUMMARY

have encountered difficulty in obtaining needed data for this purpose, particularly for aircraft other than their own products. This obstacle in obtaining needed data may tend to discourage the aerospace industry from conducting the IR&D that could lead to improved state of the art in many areas that impact LCC.

<u>DO 56 Output Data System Interfaces</u> -

In this portion of the study, no attempt has been made to track or otherwise determine the interfacing data systems which may contain HRD. The DO 56 System contains all of the basic detail data and could be obtained from this source. It is appropriate, however, to identify the DO 56 output data system interfaces as follows:

1. D047, Standard Configuration Management Program, at each Air Logistics Center (ALC)
2. D057G, Advanced Configuration Management System, at each ALC except Oklahoma City ALC (OCALC)
3. D066, Commodity Configuration Management System, OCALC
4. G033A, Aerospace Vehicle Status Reporting System, AFLC
5. D0241, Engine Configuration Management System, OCALC
6. Space and Missile Data, Space and Missile Systems Office (SAMSO)
7. Military Airlift Command (MAC) Data
8. Air Force Communications Service (AFCS) Data
9. USAF Security Service (USAFSS) Data
10. G011, Tire Improved Reliability Mathematical Model Program, Sacramento ALC (SMALC)
11. K051, Weapon System Reliability Mathematical Model Program, SMALC
12. Air Defense Command (ADCOM) Data

13. G095, Flight Safety Prediction Technique, San Antonio ALC (SAALC)

14. D038, PME Interval Analysis System, Aerospace Guidance System Maintenance Center (AGMC)

15. D057F, Program for Selected Items, at each ALC

16. G098, Maintenance Requirements Data System, SAALC

17. G081, C-5 Maintenance Data Analysis and Recording System (MADARS) Ground Processing Segment (GPS), OCALC

18. G335, AGM-69A Short Range Attack Missile (SRAM) Service Life Data Storage Retrieval System, Ogden ALC (OOALC)

In addition to the output interfaces, the D056 System receives input data from various sources as follows:

19. G001B, provides the AFM 66-1 Maintenance Data Generated at the base level

20. G001C, provides the AFM 66-1 Maintenance Data Generated at the ALC's and Contractor facilities

21. G033B, Aerospace Vehicle Inventory and Inventory Change Reporting, provides Vehicle Operating Data by Hours Flown, Landings, Sorties, and Status Information (AFR 65-110 Data)

22. D043, Master Item Identification Control System (MIICS), provides an inventory Data Base of Air Force Supply Items by stock number and part number which is used to identify and verify AFM 66-1 transactions.

23. D143B, Master Cross Reference File - Stock Control Data, provides Equipment Specialist and Division Manager Codes for D056C, C4, Master Record.

24. Other related hard copy is input in the form of punched cards, annotated DO 56 reports, and AF Form 1530 which provides master file update information and system report requests.

MAINTENANCE COST SYSTEM (MCS:H-129)

Data Manager and Directives -

The base level MCS was implemented in 1975 and is managed by the Air Force Accounting and Finance Center (AFAFC/XSM), Denver, Colorado. The functional user manual for the base level MCS is AFM 177-380 and is applicable to base level processing of MCS data on the B-3500 computer. The Automatic Data Processing Systems and Procedures - MCS, AFM 171-380, is the data automation counterpart manual.

Base Level MCS Interfaces -

The base level MCS interfaces with other base level data systems which provide the required inputs to MCS. The base level interfacing input data systems are as follows:

1. Standard Base Level Supply System (SBSS) - Reference AFM 177-206, Para. 8-6.1 and Chapter 30 also, and AFM 67-1, Vol. II, Part 2, Chapter 7, Section N
2. B-3500 Maintenance Data Collection System (MDCS) - Reference AFM 66-267 and T.O.00-20-2
3. B-3500 Maintenance Management and Control System (MMICS), Administration Sub-system - Reference AFM 66-278; or the Exception Time Accounting Sub-system - Reference AFM 66-264
4. B-3500 MMICS Status Sub-system - Reference AFM 66-278
5. B-3500 Accounting System for Operations - Reference AFM 177-370 Chapter 38

Base Level MCS Outputs and Objectives -

The base level MCS produces several reports for distribution at base level and provides an output (RCS: HAF-ACF (M&Q) 7403) transmittal file which is forwarded to the Major Command for input to the command level MCS and the CAMMIS. The objectives of the MCS are:

1. To accumulate cost of organizational and intermediate level maintenance activities by aircraft MDS

2. To provide the capability to consolidate depot and base levelMaintenance Costs at USAF level; to show total cost by MDS

3. To improve USAF and Department of Defense responsiveness to the office of Management and Budget (OMB) and Congress regarding total maintenance costs

4. To provide data for LCC

5. To improve the basis for determining whether to perform maintenance contractually or in-house

6. To provide base level maintenance cost per flying hour

7. To purify program element reporting for the 5-year force structure and the Air Force budget submission

8. To provide cost of total maintenance labor expenditures (direct, indirect, and overhead)

9. To provide the reporting system to support the CAMMIS

Base Level Information Provided to Users -

Information is provided to interested base level activities in eight different report formats. These reports include: (a) cost and man-hours for military and civilian labor; (b) material(funded and unfunded); (c) contractor maintenance; (d) government furnished material (to contractors); (e) indirect labor; and (f) overhead labor. Cumulative totals for month and for fiscal year are included in the reports. The cost and man-hours are further broken down by Workload Breakdown Structure (WBS)*, within MDS, and within Program Element Code (PEC) - Report IA. The data elements included in each of the reports are presented in Table 4. The reports reflect Workload Breakdown Structure and Work Accomplishment Category for MDS-related and Non-related costs. The categories are as follows:

	Where Reported
1. Workload Breakdown Structure - MDS Related	
Aircraft	IA
Airframe	IA
Engine	IA
Accessories	IA
Electronics/Communications (ECOM)	IA
Armament	IA
AGE (WBS is not used in current phase - will be included in later revisions)	
2. Workload Breakdown Structure - Non-MDS Related	
Supply Support	IB
Trainers	IB
Munitions	IB
CEM	IB
Missiles	IB
PME	IB
AGE	IB
Other	IB
3. Work Accomplishment - MDS Related	
Program Maintenance (MAC only)	2A
Activation/Deactivation	2A
Modification	2A

*Not to be confused with Work Breakdown Structure (WBS) as defined in MIL-STD-881A.

TABLE 4. BASE LEVEL MAINTENANCE COST SYSTEM (MCS) H-129

REPORT NUMBER	1A	1B	2A	2B	3	4	5	6
PCN SH129-	204	204	204	204	204	204	204	204
FREQUENCY	MO	MO	MO	MO	OPT.	OPT.	OPT.	OPT.
BASE ID	X	X	X	X	X	X	X	X
DATE PREPARED	X	X	X	X	X	X	X	X
AS OF DATE	X	X	X	X	X	X	X	X
PROGRAM ELEMENT CODE(PEC)	X		X		X	X	X	
MISSION DESIGN SERIES(MDS)	X		X		X	X	X	
AIRCRAFT	X							
AIRFRAME	X							
ENGINES	X							
ACCESSORIES	X							
ELECTRONICS-COMMUNICATIONS	X							
CIVILIAN LABOR	X	X	X	X	X	X		X
MILITARY LABOR	X	X	X	X	X	X		X
MATERIAL (FUNDED)	X	X	X	X			X	X
MATERIAL (UNFUNDED)	X	X	X	X				X
CONTRACTOR MAINTENANCE	X	X	X	X				X
GOVERNMENT FURNISHED MATERIAL	X	X	X	X			X	X
INDIRECT	X	X	X	X				X
OVERHEAD	X	X	X	X				X
CUMULATIVE THIS MONTH	X	X	X	X				X
FISCAL YEAR CUMULATIVE	X	X	X	X				X
HOURS	X	X	X		X	X		X
COST($)	X	X	X		X	X		X
TOTAL	X		X		X	X	X	
SUPPLY SUPPORT		X						
TRANSPORTATION		X						
MUNITIONS/ARMAMENT	X	X						
CEM(GROUND)		X						
MISSILES		X						
PME		X						
AGE	X	X						
OTHER		X						
ORGANIZATION TOTAL		X			X	X		
NON-LOCAL		X			X	X	X	
MODIFICATION			X					
REPAIR			X					
INSPECT/TEST Includes Eng. Build-Up & T.D.			X					
OTHER SUPPORT			X					
ACTIVATION/INACTIVATION				X				
RENOVATION & STORAGE				X				
MODIFICATION				X				
REPAIR				X				
INSPECTION/TEST				X				
MANUFACTURE				X				
TECHNICAL ASSISTANCE				X				
OTHER SUPPORT				X				
RESEARCH AND DEVELOPMENT				X				
SUPERVISION					X			
TRAINING					X			
DETAILS					X			
LEAVE					X			
COMP. TIME OFF TAKEN					X			
ALERT					X			
MISCELLANEOUS					X			
NON-MDS					X	X	X	
PERCENT OF TOTAL LABOR HRS.					X			
RENTS						X		
TDY						X		
CONTRACTURAL SERVICES						X		
OTHER						X		
BENCH STOCK(NON-MDS)							X	
COPAR/COCESS/OTHER(LP)							X	
AVGAS(NON-FLYING)							X	
CUMULATIVE TO DATE							X	
BUDGET							X	
PERCENT OF BUDGET							X	
CUSTOMER(MAJ. COMD/AGENCY)								X
TENANT TOTAL								X
TRANSIENT TOTAL								X
TOTAL OTHER								X
GRAND TOTAL								X
*PROGRAMMED MAINTENANCE				X				

*MAC only

Repair	2A
Inspection and Test	2A
Technical Assistance	2A
Other Support	2A
Research and Development	2A
4. Work Accomplishment - Non-MDS Related	
Activation/Deactivation	2B
Renovation and Storage	2B
Modification	2B
Repair	2B
Inspection and Test	2B
Manufacture	2B
Technical Assistance	2B
Other Support	2B
Research and Development	2B
5. Indirect Labor Category - Category (Military - Civilian)	3
Supervision	3
Training	3
Detail	3
Leave	3
Compensatory Time Taken	3
Alert	3
Miscellaneous	3
6. Overhead Category	4
Military Labor	4
Civilian Labor	4
Rents	4
Temporary Duty	4
Contract Services	4
Other	4

<u>Base Level MCS Labor Hours and Cost Data</u> -

The indirect and overhead labor hours and cost data are distributed to PEC, MDS, Non-MDS, and Non-Local, based on direct labor hour ratios. The "By Customer Report" reflects cost data for tenant support (by Command), Transient Support (by Command), and other support (identified to activity supported). Maintenance organizations that do not process MDCS or MMICS Admin/ETA System on the B-3500 (for example, B263 bases) are not applicable to the MCS. For example, the cost of maintenance performed by the Air National Guard is not included in MCS. Associate reserve personnel on active duty in support of an active Air Force mission and Air Force Reserve (AFRES) activities that are tenants on Air Force bases are costed in the MCS. All other AFRES and all Air National Guard (ANG) activities who process the MDCS and MMICS Administrative System on the

B-3500 are included in the MCS for CAMMIS reporting only (Non-MCS reportable). A general system flow process for this system is presented in Figure 5.

Command Level Maintenance Cost System (MCS:H-129A/YO) -

The Command level functional user documentation is AFM 177-679, USAF Standard Major Command Level Maintenance Cost System (H6000). AFM 171-679 is the Automatic Data Processing Systems and Procedures in support of the H6000 MCS at the Major Command (MAJCOM) level. The Command level MCS accepts the base level MCS:H-129.

HAF-ACF(M&Q)7403 reports and consolidate the data by categories to produce command wide maintenance cost data. This system produces seven reports at Command Level and also produces an output to USAF headquarters which is used as an input to the OSCR. The same cost elements and cost categories used at base level are used at Command Level. The difference in the report formats is that the Command MCS reports reflect cost only and do not contain labor hours. A general system flow process for this system is presented in Figure 5.

Command Aircraft Maintenance Manpower Information System (CAMMIS) -

The CAMMIS receives data from three sources: MDCS; MMICS Administration Subsystem or the Exception Time Accounting (ETA) System; and the MMICS Status Subsystem or the Aerospace Vehicle Status Report (AI). These base level systems feed the CAMMIS data elements to MCS monthly. The MCS transmits the CAMMIS data elements to MAJCOM as a part of the RCS:HAF-ACF (M&Q)7403 report. Output from CAMMIS is transmitted to USAF/PRMP for input to the Aerospace Maintenance Manpower Information System (AMMIS). This system provides information at Air Force level for planning and budgeting personnel cost and allocation of manpower resources.

Visibility and Management of Operating and Support Costs (VAMOSC) -

Purpose of VAMOSC

The AFLC H036 System, a portion of VAMOSC, provides depot

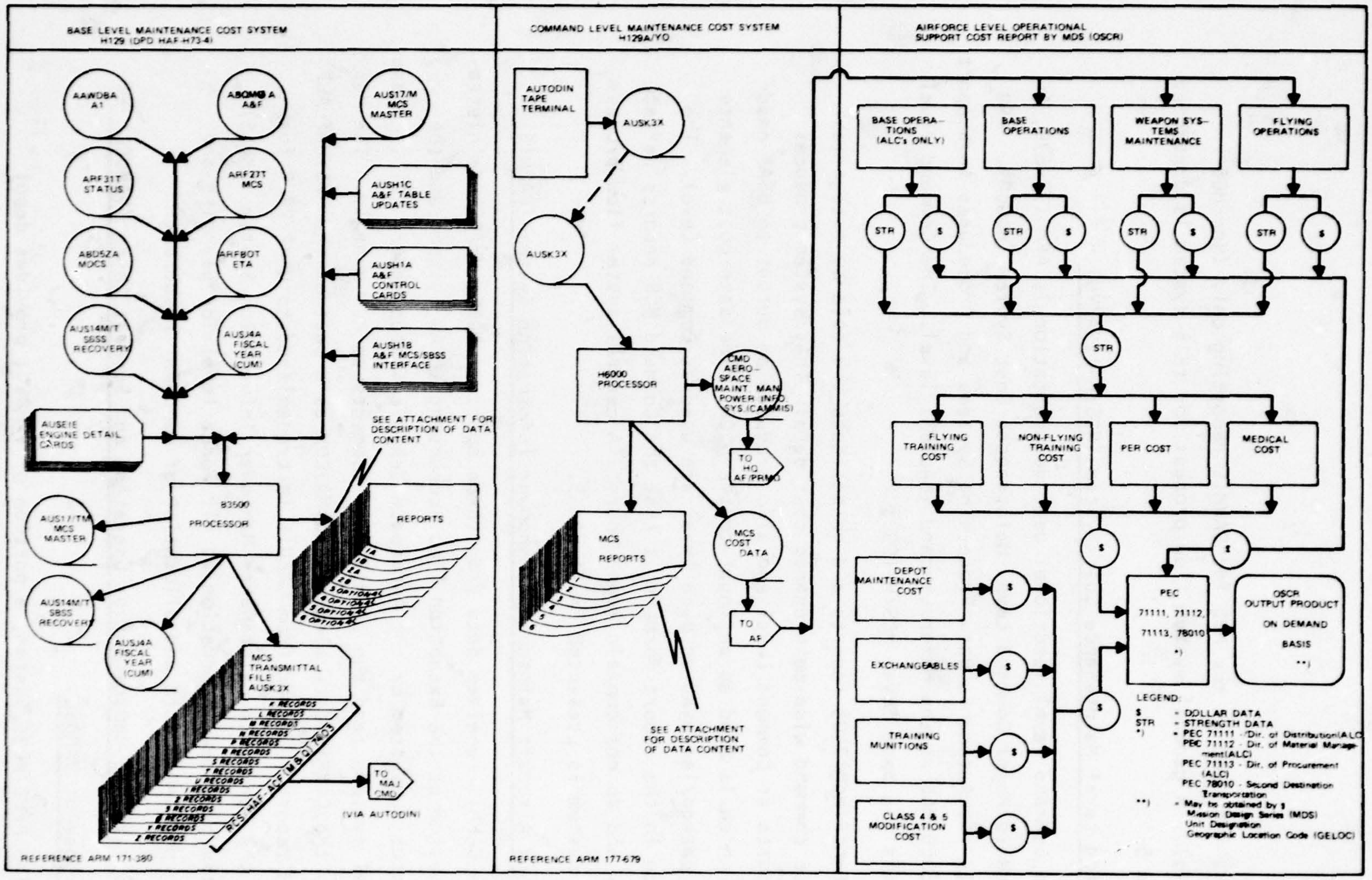

Figure 5. Maintenance cost system

maintenance cost data which are input to Air Force for inclusion in the Air Force level OSCR. The VAMOSC System is still undergoing development and is currently identified as H036C. The stated purpose of this system is to "collect on a quantity basis, Depot Maintenance Costs, Depot Management and Supply Costs, and Aircraft/Missile inventory and utilization data. These data are used to produce total and unit cost of operation and maintenance of Weapon Systems."

VAMOSC Input Interfacing Systems -

The input interfacing systems are:

1. D041, Recoverable Consumption Item Requirements System
2. G033J, Past Program Data System
3. G311, AF Level AVISURS Reporting System
4. H036B, DMIF Cost Accounting Production Report (AFLC)
5. H069, General Accounting System - Base
6. K004, Development of Program Data for Consumption Item Requirements Computation (Input to D041)

A general system flow process is presented in Figure 5. The prescribing directives for this system are PMD A-7067 and ACR-H77-5, neither of which could be obtained.

Operating and Support Cost Report (OSCR) - Air Force Level -

The OSCR merges the total operating and support cost data for Weapon Systems by MDS. Since this system is undergoing development, it was very difficult to obtain its current status. In addition, formalized documentation (regulations/manuals) describing the system could not be located. The OSCR System Design Schematic is presented in Figure 5. A general system flow process for the development of depot maintenance cost data is reflected in Figures 6 and 7, with the attendant matched and unmatched files identified. Informal discussions with AFLC personnel indicated that Figures 5, 6 and 7 are basically a fair representation of the system. The output shown in Figure 7 is used as input by Headquarters USAF to produce OSCR outputs shown in Figure 8, Figure 8 shows the type data provided for each aircraft type for a given year.

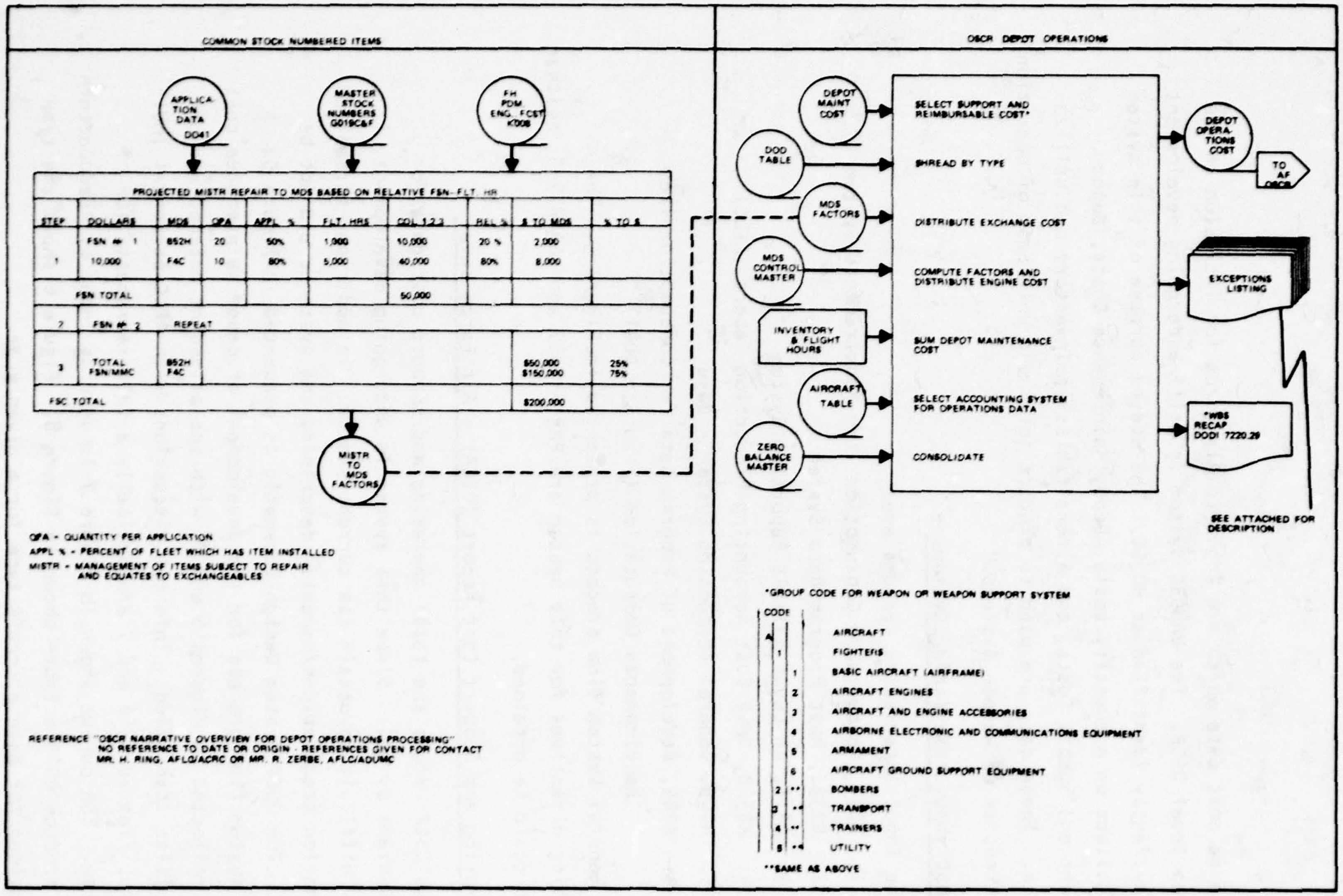

Figure 6. Operating and support cost report

ADIL-FY-- Non-Reportable Items List
AGIL-FY--Unmatched Aircraft/Missile MDS List
BGIL-FY--Unmatched Exchange Item List
BG2L-FY--Unmatched Exchange Factor List
CGIL-FY--Unmatched Inventory/Flying Hour List
CJIL-FY--Unmatched MDS Control Master
CJIL-FY--Unmatched TMS Cost list
DDIL-FY--DS, MM, PP, & Base Operating Support Cost List
EDIL-FY--Depot Maintenance Cost*-WBS Recap by MDS
TGIL-FY--Unmatched Aircraft Table MDS

WEAPON SYSTEM -

*	BASIC AIRCRAFT	ENGINES	ACFT & ENG. ACCESSORIES & COMPONENTS	ELECTRONICS & COMMUNICATIONS	ARMAMENT	GROUND SUPPORT EQUIPMENT
Direct Civilian Labor Cost	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX
Direct Military Labor Cost	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX
Exchange Mat. Cost	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX
Gen. & Admin. Cost	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX
Overhead Cost	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX	XXXXXXXXX XX.XX
Total Organic Cost	XXXXXXXXXXX XXXX.XX	XXXXXXXXXXX	XXXXXXXXXXXX	XXXXXXXXXXX	XXXXXXXXX	XXXXXXXXXX
Contract Cost	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
GFM/GFS Cost	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
Total Contract Cost	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX
Total Maintenance Cost	XXXXXXXXX	XXXXXXXXX	XXXXXXXXXX	XXXXXXXXX	XXXXXXXXX	XXXXXXXXX

(MDS) Total Deport Cost $XXXX.XX (Excluding Exchange Material)
Average Possessed ACFT XXX.XX
Flying Hours XXX,XXX
Depot Cost/Flying Hour $XXX,XXX
Sorties XXX,XXX
Depot Cost/Sortie $XXX,XXX

Figure 7. Depot maintenance cost data system - OSCR

Base Level Operations - Type Aircraft As of Date

MDS	Fly hours	Landings	Sorties	Avg. No. Aircraft Possessed
XXXXXX	XXXXX	XXXXX	XXXX	XX.XX

	Officer	Enlisted	Tot Mil	Civilian	Supplies	TDY	Contract	Other	Total
Flying ops	2I836I49	I0067I74	3I903323	III0872	50589I42	I30567I	XXXXXXXX	XXXXX	84909000
Aircrew	I2267575	II99240	I3466815	XXXXXXX	2I05499	I30567I	XXXXXXXX	XXXXX	I6877985
Unit Admin/SPT	37940I8	4I37999	79320I7	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	79320I7
Ops staff	5773756	4729935	I050369I	III0872	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	II6I4563
Pol	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXX	48483643	XXXXXXX	XXXXXXXX	XXXXX	48483643
Weapon syst maint	I969669	30752995	32722664	82I608	755I967	I40434	XXXXXXXX	XXXXX	4I236673
Consolidated	72I	2924I	29962	XXXXXXX	433I	XXXXXXXX	XXXXXXXX	XXXXX	34293
Organizational	266427	589060I	6I57028	3I2264	I095304	XXXXXXXX	XXXXXXXX	XXXXX	7564596
Field	I86280	7I238I0	73I0090	3I4827	30989II	XXXXXXXX	XXXXXXXX	XXXXX	I0723828
Avionics	2776I6	6532836	68I0452	I23267	2706I30	XXXXXXXX	XXXXXXXX	XXXXX	9639849
Munitions	478699	78256I3	83043I2		5545I0	XXXXXXXX	XXXXXXXX	XXXXX	8858822
Chief	759926	3350094	4II0020	7I250	9278I	I40434	XXXXXXXX	XXXXX	44I5285
Base level bos	I354359	II247848	I2602207	I0339809	6307835	35822	2I0232I	I443332	3283I326
Real prop	275237	3036545	33II782	6797065	485838I	I0995	I644468	I28I0I4	I7903705
Communications	30709	54326I	573970	30733	I0008	322	XXXXXXX	XXXXXXX	6I5033
Housekeeping	I0484I3	7668042	87I6455	35I20II	I439446	24505	457853	I623I8	I43I2500
Training	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXX	XXXXXXX	29098495	29098495
Flying status	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	I52639II	I52639II
Officer	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	I482224I	I482224I
Gen acq & trn	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	8887889	8887889
Advanced trn	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	5934352	5934352
Enlisted	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	44I670	44I670
Gen acq & trn	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	6I770	6I770
Advanced trn	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	379900	379900
Non-flying status	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	I3834584	I3834584
Officer	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	3578386	3578386
Gen acq & trn	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	238I686	238I686
Advanced trn	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	II96700	II96700
Enlisted	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	I0256I98	I0256I98
Gen acq & trn	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	2456306	2456306
Advanced trn	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	7799392	7799892

Figure 8. Operating and support cost report (OSCR) FY

	Officer	Enlisted	Tot Mil	Civilian	Supplies	TDY	Contract	Other	Total
Other personnel support	XXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXX	XXXXXXXX	8844309	8844309
PCS	XXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXX	XXXXXXXX	5839629	5839629
Officer	XXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXX	XXXXXXXX	I58I228	I58I228
Enlisted	XXXXXX	XXXXXXX	XXXXXXX	XXXXX XX	XXXXXXXX	XXXXX	XXXXXXXX	425840I	425840I
Medical	866457	II02278	I968735	350220	350220	27429	294273	I3803	3004680
Officer	2I4533	233046	447579	82764	82764	6534	68607	5445	693693
Enlisted	65I924	869232	I52II56	267456	267456	20895	225666	8358	23I0987
Total base level									I969I98II

Depot Operations - Type Aircraft

As of Date

MDS	Fly hours	Landings	Sorties	Avg. No. Aircraft Possessed
XXXXXX	XXXXX	XXXXX	XXXX	XX.XX

	Officer	Enlisted	Tot Mil	Civilian	Supplies	TDY	Contract	Other	Total
Recurring Investments	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX	XXXXXXXX	56I22504	56I22504
Exchangeables	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX	XXXXXXXX	637I990	657I990
Training Munitions	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX	XXXXXXXX	9I64330	9I64330
Modifications-IV & V	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX	XXXXXXXX	3797I093	3797I093
Component Improvement	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXXX
MOD initial spares	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXX	XXXXXXXX	26I509I	26I509I
ALC bos	36257	I75857	2I2II4	894472	I68I08	4828	2535I2	I08727	I64I76I
Real Prop	9382	58372	67754	470993	I4202I	883	23I450	I07288	I020389
Communications	8034	6I334	69368	80042	6258	I789	320	26	I57803
Housekeeping	I884I	56I5I	74992	343437	I9829	2I56	2I742	I4I3	463569
ALC directorates	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXX	XXXXXXXX	45I63I	45I63I
Distribution	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXX	XXXXXXXX	282708	282708
Material mgmt	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXX	XXXXXXXX	I237II	I237II
Procurement	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXX	XXXXXXXX	452I2	452I2
Second dest trans	XXXXXXX	XXXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXX	XXXXXXXX	46263I	46263I

Figure 8 (Continued). Operating and support cost report (SCR) FY

	Officer	Enlisted	Tot Mil	Civilian	Supplies	TDY	Contract	Other	Total
Other depot ops	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXX	XXXXXXXX	XXXXX	58678527
Total unit costs									301371585

Costs which are not distinguishable between Officer, Airmen, Civilian pay, Supplies, etc. are displayed in the "Other" column. For this reason, no grand total by column is meaningful. This problem is currently under study.

AFLC Depot Maintenance

MDS	Fly hours	Landings	Sorties	Possessed
XXXXXX	XXXXX	XXXXX	XXXX	XX.XX

	Officer	Enlisted	Tot Mil*	Civilian	Supplies	TDY**	Contract***	Other	Total
Airframe incl POMI	XXXXXXX	XXXXXXXX	44499	0673576	I068593	XXXXXXX	I39440	8329662	I8244770
Variable	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX
MDS	XXXXXXX	XXXXXXXX	44499	0673576	I068593	XXXXXXX	I39440	8329662	I8244770
Engines	XXXXXXX	XXXXXXXX	33499	40880I	308020	XXXXXXX	XXXXXXXX	580I35	I330455
Variable	XXXXXXX	XXXXXXXX	XXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXX	XXXXXXX	XXXXXXXX
Fly hours	XXXXXXX	XXXXXXXXX	33499	40880I	308020	XXXXXXX	XXXXXXXX	580I35	I330455
Accessories	XXXXXXX	XXXXXXXXX	I6845	5704382	4895486	XXXXXXX	I7I924I	55I7952	I7853906
Variable	XXXXXXX	XXXXXXXXX	XXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXXX	XXXXXXX	XXXXXXXX
MDS	XXXXXXX	XXXXXXXXX	5895	I996534	I7I3420	XXXXXXX	60I735	I93I283	6248867
Fly hours	XXXXXXX	XXXXXXXXX	I0950	3707848	3I82066	XXXXXXX	III7506	3586669	II605039
Elect & comm	XXXXXXX	XXXXXXXXX	44I	598439	88I879	XXXXXXX	202564	538555	222I878
Variable	XXXXXXX	XXXXXXXXX	XXXXX	XXXXXX	XXXXXXX	XXXXXXX	XXXXXXXXX	XXXXXXX	XXXXXXXX
MDS	XXXXXXX	XXXXXXXXX	I54	209454	308657	XXXXXXX	I96076	I88494	902835
Fly hours	XXXXXXX	XXXXXXXXX	287	388985	573222	XXXXXXX	6488	35006I	I3I9043
Armament	XXXXXXX	XXXXXXXXX	2042	I582720	I988967	XXXXXXX	84909I	I374959	5797779
Variable	XXXXXXX	XXXXXXXXX	XXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXXX	XXXXXXX	XXXXXXX
MDS	XXXXXXX	XXXXXXXXX	2042	I582720	I988967	XXXXXXX	84909I	I374959	5797779
Ground support	XXXXXXX	XXXXXXXXX	42	55I25	64530	XXXXXXX	I39I92	54570	3I3459
Variable	XXXXXXX	XXXXXXXXX	XXXXX	XXXXXXX	XXXXXXX	XXXXXXX	XXXXXXXXXX	XXXXXXX	XXXXXXX
MDS	XXXXXXX	XXXXXXXXX	I6	I9294	22586	XXXXXXX	487I7	I9099	I097I2
Fly hours	XXXXXXX	XXXXXXXXX	26	3583I	4I944	XXXXXXX	90475	3547I	203747
Total									45773247

Figure 8 (Concluded). Operating and support cost report - FY

*Costs available by total military only

** Included in "Other" column

*** Includes contract SVS and CFH

USAF COST AND PLANNING FACTORS (AFR 173-10)

The VAMOSC, of which OSCR is a part, is used to update the cost and planning factors contained in AFR 173-10, as is the base level MCS data. Currently AFR 173-10 provides the only source for certain data elements required for input to the CACE Model for estimating LCC.

Cost factors from AFR 173-10 have also been used successfully to develop CERs for cargo/transport aircraft for estimating Base Material Cost, Replenishment Spares Cost, Replacement Common Support Equipment and Spares Cost, Base Level Fuel and Oil Costs, Initial Base Level Support Equipment (formerly AGE) Costs and Base Level Support Equipment Maintenance Cost (in terms of MMH/FH).

LOGISTICS SUPPORT ANALYSIS (LSA) - MIL-STD-1388-1

The data recording and documentation requirements, resulting from the application of MIL-STD-1388-1, is one of the most valuable sources of information identified in this research. The accumulation of these data during future acquisition programs will aid in the development of a historical data base needed to fully support the acquisition process in conjunction with other historical data such as AFM 66-1 and MCS data. This data system will permit the assessment of R&M predictions, allocations, demonstrations, and field performance (after deployment), from the early development phase throughout the life of the vehicle. This capability does not currently exist in sufficient numbers of aircraft to represent an adequate data base.

The application of Integrated Logistics Support (ILS), and the development of a common data base to serve both the "designer" and the "improver" were recommended in attachments to the Memorandum from the Vice-Chief of Staff, Subject: Institutionalization of Life Cycle Cost and Other Considerations in Program Management, dated 23 January, 1978. A common historical data base developed from the prescribed LSARs by MIL-STD-1388-1, could best serve the purpose stated in the referenced memorandum. This study failed to identify an existing directive to require the application of MIL-STD-1388-1 to major procurement programs. It is understood, however, that AFR 800-3 is currently undergoing revision and will require the application of MIL-STD-1388-1 on all major programs.

SYSTEM EVALUATION DATA SYSTEM (SEDS)

The SEDS is operated by the Air Force Test and Evaluation Center (AFTEC) at Edwards Air Force Base, California. This system is primarily designed to capture operational and maintenance data generated during the Category II Flight Test Program. The source document for maintenance data collection is the AFSC Form 258. The AFSC Form 258 contains all of the data elements that are recorded on the AFTO Form 349, plus additional information relative to the adequacy of the Support Equipment, Technical Data, and up to three specific Air Force Specialty Codes for trouble-shooting and repair. For failure removals, the failed item noun and manufacturer's code, next assembly part number, next assembly serial number, next assembly noun, and next assembly manufacturer's code is also captured. Operational time at failure, severity of the failure, type failure, analysis required, and disposition of the failed item are reported. The total downtime associated with removal or repair actions are recorded and separated into troubleshoot time and repair time. The SEDS utilizes these data from the AFSC Form 258. In addition, SEDS uses the standard data elements recorded on the AFTO Form 349 for the AFM 66-1 MDCS with the exception of start and stop time, crew size, employee number, and data used only in MCS.

The SEDS generates similar reports relative to maintenance as are produced at base level from the MDS. There are some differences in report formats (such as active maintenance downtime, elapsed time per task, and mean crew size) which do not appear in any of the MDS reports. The SEDS data base is used to evaluate and verify the achievement of R and M requirements, or goals, during the Category II, Verification Test and Demonstration. The only documented description of this system that our research identified was SAMSO-TR-69-239, August 1969, in two volumes: SEDS - System Effectiveness Data System; Volume I, Management Analysis and Program and Volume II, User Documentation and Implementation Instructions.

SECTION III

AFLC DATA BASES

GENERAL

This section identifies important ancillary data base developments that were not addressed in Section II. The AFM 66-1 MDCS identified in Section II is the primary source of historical data that are useful and usable in the design process. These data, properly utilized, can greatly assist in design decision making where Logistics Support, R&M and O&S costs are major considerations or are used as trade-offs with design performance characteristics. The DO 56 system provides the largest data base in terms of types of equipment for almost any time period of interest. The data are stored on magnetic tape and can be processed by AFLCs existing programs and equipment.

There are two other existing data base developments that are or could be utilized to influence design and development of future systems and equipment. These are the Integrated Logistics Data File (D 194) and the Special Purpose Data Bases of AFLC.

INTEGRATED LOGISTICS DATA FILES

In addition to the DO 56 data base, at least four unique Integrated Logistics Data Files (ILDF) have been developed as a part of the D 194 system. The four files for the A-10, B-1, F-16 and F-15 are identified as D 194A, D 194B, D 194C and D 194D, respectively. The basic D 194 system currently under development is intended to be applicable to any aircraft in future procurements. This will eliminate the need to establish a unique file for each aircraft as has been done previously. A review of the data elements used by this system, however, indicates that the D 194 is not being designed around the requirements of MIL-STD-1388-1.

The D 194 has a total of 388 data elements identified, of which 232 are contractor generated and 156 are AFLC in-house data elements. The system is being designed to provide the following:

Support Equipment Requirements and Status

Engineering Change Proposal/TCTO and Kits Requirements/Status

Spares Support Requirements

Preservation, Packing and Shipping Information

Projected Depot Level Maintenance Workload Information

Technical Order Status and Delivery Information

Delivery schedule information is included for each of the categories input. The portion missing from the D 194, which is essential to a Human Resources Unified Data Base, is R, M, operations task analysis, and facilities information.

SPECIAL PURPOSE DATA BASES

AFLC data systems developed to support specific requirements are identified below by DSD number, title and status. A brief description of the use of each data base is provided.

DSD Number	
A001	F-16 Avionics Integration Support Facility System. Status: Under Development Use: Provides software for F-16 avionics Operational Flight Program (OFP) and OOALC avionics integration and support facility. Consists of OFP tape generation, simulations, data reduction and analysis.
A001A	Utility Software Support F-16 Avionics Operational Flight Program. Status: Under development Use: To conduct Real-Time Dynamics Simulation Testing of OFP to verify software.
A001B	F-16 Postflight Test Data Reduction and Analysis. Use: Reduction of data collected by test aircraft giving printout and data tape to engineering units to evaluate Navigation/Air Combat Maneuvering etc.

A105 Utility Software Support F-4 Avionics Operational Flight Programs.

Status: Under development

Use: Provides software for R/RF-4 Avionics OFP and OOALCs Avionics and Integration Support Facility (AFIF-4). Consists of OFP tape generation, simulations, data reduction, and analysis.

A015A Dynamic Simulation Area Post Computer Software Support.

Status: Under development

Use: Used to conduct real time dynamic simulation testing of OFP to verify software. Largely independent of the avionics interface.

A015B F/RF-4 Avionics Support Postflight Test Data Reduction and Analysis.

Status: Under development

Use: Reduction of data collected by F-4F and RF-4C test aircraft giving printout and data tape to engineering units to evaluate navigation, air, combat maneuvering. Long range air-to-air intercepts and air-to-ground weapon release.

A022 Non-Nuclear Munitions Environmental Test Data Reduction.

Status: Operational

Use: Reduces data collected from live tests of non-nuclear air munitions to meaningful products that portray effectiveness.

A047F Maintenance Information Logically Analyzed and Presented (MILAP).

Status: Operational

Use: MILAP is time oriented maintenance system. The modular subsystem structure of MILAP facilitates changes/modifications with minimal disruption to the existing system.

A354 F-III OFP

Status: Operational

Use: This system aids Mission Programming organizations in preparing and correcting F-III OFP and is used to analyze F-III flight data recorded during flight testing and dynamic simulations. The OFPs are used to control the three onboard digital computers that are utilized in the MARK II Avionics System. These systems are recorded on punched tape and loaded into the computer cores. Mission Programming rganizations write the OFPs in assembly languages which are translated to object code.

B020 Scientific Data Processing.

Status: Operational

Use: This data system is applicable to all research and development applications programmed to run on computer systems. OOALC, as host to the 6514th Test Squadron, uses this system in support of the remotely piloted vehicle test program.

B456 Systems Effectiveness Data System.

Status: Operational

Use: A set of computer programs designed to assist in the analysis of reliability and maintainability data. The Quantitative Reliability Programs provide non-parametric statistics.

C004 Air Force Equipment Allowance Management System.

Status: Under development

Use: Provides for automation of the Support Equipment Allowance Program and establishment of an interactive capability to furnish reliable, correlated and timely data to all Air Force activities worldwide. Maintains allowance data for all items of support equipment that are technically of functionally required to maintain, repair, overhaul, test or calibrate any weapons system, subsystem, end item, function or mission within the Air Force. This is a prototype system which will be service tested and evaluated. If successful and approved, will replace present COOIE System.

C013 Support Equipment Acquisition and Control System.
Status: Operational
Use: Provides Support Equipment item management information to support a given weapon system from acquisition to initial lay-in before need date.

C104 Automatic Test Equipment (ATE) Data Bank.
Status: Operational
Use: ATE data bank provides a tool to identify existing ATE which has the capability to satisfy a given set of electrical test requirements for existing or new weapons system. Defined test requirements for a unit under test are coded and read by the computer program which compares the test requirements for the unit under test (that is, the Line Replaceable Unit (LRU) and Shop Replaceable Unit (SRU) with ATE testing capability for the ATE systems in the data bank. System is used by the ATE/SM at SAALC.

D024A Propulsion Unit Data Collection Status Reporting (AFM 400-1).
Status: Operational
Use: Accomplishes data collection, file maintenance and evaluation for all DO 24 Systems except D024L.

D024F Propulsion Unit Actuarial Experience Computation.

Status: Operational

Use: Tabulates engine exposures and removals, computes hours flown per failure to failure rates experienced during the period, and computes new official overhaul rates.

D024K Propulsion Unit Actuarial Forecast Computations.

Status: Operational

Use: Forecasts engine removals and replacement requirements by applying computed actuarial failure rates to projected installed engine inventory by age interval and cycle.

D041 Recoverable Consumption Item Requirements System.

Status: Operational

Use: System computes replenishment requirements for recoverable items. Accomplishes stratification products for preparation of budget/apportionment submissions: computes war readiness requirements.

D042B Propulsion Unit Diagnostics and Conditioning Monitoring.

Status: Under development

Use: Maintain engine/module performance, history, tables, and analysis of airborne/ground diagnostics system reliability. Maintain engine/module spectrometric oil analysis programs and bore scope history.

D043 Master Item Identification Control System

Status: Operational

Use: Central repository of Air Force material identification and supply management; generates and releases stock list changes based on DIDs approved changes.

D051 Reliability Improvement Warranty Performance Evaluation

Status: Under development

Use: Provides Automated Data Processing (ADP) support to AFLC activities involved in validation of Reliability Improvement Warranty (RIW) Contractor Performance. Compiles statistical data to support follow-on Logistics Support Planning and produces periodic reports for analysis and evaluation of the RIW concept.

D057F	Actuarial Program for Selected Items. Status: Operational Use: System collects, maintains and reports usage and failure data on high cost or critical serialized components identified by the system manager for actuarial studies.
D060	Microfilm Mechanized Engineering Data for Automated Logistics Systems. Status: Operational Use: Provides ALCs, Air Force Bases, and stations with engineering data required to support their mission through the medium of microfilm aperture cards (PCAM System). Engineering Data Requisition and Index System, DAR LOG-MMO/D74-100, if approved, will replace D060.
D194D	Mechanized Support Items List. Status: Under Development Use: Support of F-15 Weapon System Manager to accomplish provisioning, management information, and historical information storage and retrieval.
D220	AFLC Provisioning System. Status: Under development Use: A management system for determining and acquiring the range and quantity of spare/repair parts necessary to support the equipment for an initial operational support period.

F010	Technical Training Management Information System (TRAMIS). Status: Operational Use: TRAMIS is an automated technical training subsystem of the Advanced Personnel Data System (ADPS) to provide capabilities for central control of requirements and allocations of training quotas for all Air Training Command (ATC) technical training courses from a central training quota bank.
F-776	Computer Directed Training System (CDTS) Status: Operational Use: A system defined as using the capabilities of a computer to present instructional material to trainees who interact via a remote terminal device. The system is currently operated as an on-line B3500 System.
G008	Solid Propellant Rocket Motor Test System Status: Operational Use: The system acquires and reduces data derived from the testing of rocket motors and explosive components. The reduced data are used for engineering evaluation of service life extension and weapon system modification.
G012	Computation Support For CREATE Engineer Computations Status: Operational Use: This is a time-sharing system to support workloads of the engineers and technicians of AFLC. This includes engineering design, both computational and logical selection techniques; information retrieval such as creation, storage and access of data banks; analysis of engineering problems to determine current performance,past trend and future projections; reliability techniques; and mathematical, physical, and social sciences as they relate to engineering integrated systems.

G012A Computation Support For CREATE Logistics Research.

Status: Operational

Use: This is a time-sharing system to support logistics research workloads which includes: programming, debugging and testing mathematical and simulation models of logistics processes and procedures; performing statistical, graphical, and other analysis of collected historical data; and providing computational support for the application of various Operations Research, Mathematical and Statistical Techniques.

G026 Material Improvement Project (MIP) Status Report.

Status: Operational

Use: The material improvement project system provides for the processing of status records on MIPs established as a result of deficiencies reported on Air Force equipment in accordance with T.O. 0035D-54 and AFM 66-1.

G047 Automatic Test Equipment Support.

Status: Operational

Use: This system provides computer aided support to Mission Programming organizations during preparation of correction of ATE test programs. Also maintenance of ATE support software used to develop or compile test programs. System is currently being supported on various computers at the ALCs and at AGMC on 360/50 and B3500. RJE terminals to be linked to OOALC 360/65 from each ALC are being acquired as the standard computer equipment to support the ALCs ATE requirements. AGMC Support will continue on 360/50/B3500.

G081 C-5 Malfunction Detection Analysis and Recording System - Ground Processing Segment (MADARS/GPS).

Status: Operational

Use: System provides inflight aircraft status and trouble shooting information while generating a permanent record of LRU status. MADARS shows current performance of selected systems, performs engine health diagnosis, identifies discrepant LRUs, records trend data, determines its C-5A health, calibrates the total monitoring system and provides for data storage and retrieval. A ground computer system process inflight data recorded on tapes, evaluates the trend data, and develops programs to utilize the experience data.

G086A Individual Aircraft Service Life Monitoring Program.

Status: Operational

Use: System is designed to process individual aircraft flight utilization, transcribed manually, describing mission profiles. Data are key punched and processed, fatigue damage is calculated based on damage rate tables obtained from cyclic test results. Information which reflect individual aircraft fatigue damage by serial number is produced for use by the Aircraft Structural Integrity Program (ASIP) to schedule inspections, repairs/modifications or phase out of the aircraft.

G086B Service Loads and Life History Recorder Program.

Status: Operational

Use: System is designed to process flight recorder data reflecting aircraft operational flight conditions. Data are used to assess the validity of the aircraft operational environment and associated loads which were used initially to perform parametric analyses and to develop damage coefficients. Data are collected via several different airborne recorder systems.

G086C Exceedance Counter Program.

Status: Operational

Use: System utilizes data collected from aircraft equipped with G-load counting systems. Data are collected by ground personnel after each flight or a specified time period and sent to OCALC for editing and processing. Fatigue damage is calculated and information produced for use by the ASIP.

G086D ASIP For Landing Gear.

Status: Operational

Use: System is designed to provide fatigue damage information on landing gear components. This is accomplished by collecting recorder data, reducing the data to define landing spectrums and computing fatigue damage at critical points by mission segment. Mathematical analysis of reduced recorder data and fatigue damage are accomplished to provide management data.

G089 Damage Tolerance Analysis.

Status: Under development

Use: Provides for use of a series of batch programs to isolate critical areas in an aircraft structure and predict crack propagation rates for a given operating environment. One of those programs will also provide ALC System Managers with an analysis of complex general structure problems as they occur.

G095 Flight Safety Prediction Technique.

Status: Operational

Use: Provides a means to assess/determine the safety of aerospace systems before accidents occur.

G097 Elapsed Time Indicator/Event Counter Data Collection and Utilization

Status: Operational

Use: To collect and assimilate data from which true causes of failure of elapsed time indicator/even counter equipped items can be determined/developed and operated only at OCALC.

G337 Cyclic Reporting and Fatigue Tracking - F-100 Engine Modules.

Status: Operational

Use: This system provides cyclic reporting and fatigue tracking for F-100 engine modules and selected life-limited engine components.

Each of these systems provides a source of information and each has established a historical file of the type of data the system was designed to process. As previously stated, the identification of data that are useful and usable in the design process is largely dependent upon individual judgements. The systems identified are not all of the systems operated by AFLC. They represent those, in our judgement, that may provide the most useful information to the design engineer. Herein would appear to be a major step toward the "bridge" between the AFSC design-oriented engineers and the AFLC System improvement engineers (Reference Department of the Air Force Memorandum for Vice-Chief of Staff, Subject: Institutionalization of Life Cycle Cost and Other Logistics Considerations in Program Management, dated 23 January 1978). The data systems described are obviously systems-improvement oriented. These systems collectively provide an invaluable source for "lessons learned" in terms of good performance versus poor, or high versus low LSC for weapons systems, subsystems and components. These systems are in addition to the primary data systems such as the DO 56, KO 51, H036B, H-129 and OSCR.

AFALD PAMPHLET 800-4

The most recent data base development was accomplished by the Air Force Acquisition Logistics Division (AFALD), and the data base contents were published in AFALD PAMPHLET 800-4, Acquisition Management Aircraft Historical Reliability and Maintainability Data, dated September 1978.

The data were compiled for the majority of the aircraft currently in the

Air Force inventory covering a 6 year period (except those entering the inventory during the period covered) from 1 April 1972 through 31 March 1978. The data are presented at the two-digit work unit code level in six month increments by type aircraft using the standard MDS groupings.

SECTION IV

MAJOR DATA SOURCES OTHER THAN AIR FORCE

GENERAL

It sometimes becomes difficult to distinguish between a data source and a program that has been developed to process, analyze, integrate, and reformat data from other data systems to serve a specific need. The information provided as output from such programs could be considered a data source if the information is useful and usable to the design process.

The programs identified in this section were developed to support specific needs as a part of recent data base development efforts. Each of these programs represent some form of a data base and could be drawn upon as a data source if and when needed.

ARMY DATA

THE ARMY MAINTENANCE MANAGEMENT SYSTEM (TAMMS)

TAMMS is very similar to the Air Force MDCS. Although the forms used to record the maintenance data are different from the AFTO Form 349, the data elements used are comparable except for the Air Force MCS data elements. The TAMMS collects data on most equipment maintained by the Army. Recently however, the reporting of organizational level (unit level) maintenance has been eliminated on equipment other than aircraft. Complete reporting for aircraft maintenance is still required. On equipment other than aircraft, only intermediate and depot level maintenance is reported.

All TAMMS data worldwide is processed at the Army Maintenance Management Center, Lexington Bluegrass Army Depot, U.S. Army Material/Development and Readiness Command (DARCOM), Lexington, Ky.

At the organizational level, the Army has implemented a sampling program to obtain maintenance data on selected equipment. The objective of this program is to obtain the data required to assess the performance, effectiveness, reliability, maintainability, availability, life cycle cost and support of the equipment selected for sampling. Reporting under Sample Data Collection (SDC) is in accordance with Army Regulation 750-37.

LOGISTICS SUPPORT ANALYSIS COMPUTERIZED PROGRAM

In addition to the TAMMS, the Army has developed a very comprehensive Logistics Support Analysis Computerized Program designed around the requirements of MIL-STD-1388-1. This system will accept and process all data required to complete the LSARs in the formats prescribed by MIL-STD-1-1388-1, data sheets A through H. The Army Material Command (AMC) Guide to Logistics Analysis,AMC Pamphlet 760-16, describes the LSA/LSAR Procedures. The Air Force is currently using the Army LSA/LSAR Program on ten (10) major weapon system acquisition programs. Each of these systems represent a valuable source of data for the establishment of a historical data base to be used in the comparability analysis of future procurement of comparable or similar systems, subsystems and components. Of particular value is the task analysis and support equipment requirements generated through the contractor's LSA/LSAR's.

NAVY DATA

NAVAL AVIATION MAINTENANCE PROGRAM (NAMP)

The Navy Maintenance Data System is the most complex and detailed of the three services. The NAMP System is described in Navy Manual OPNAVINST 4790-2A, Volumes I, II and III. Volume I outlines policies, concept, organization, and responsibilities. Volume II contains the Maintenance Support Procedures, and Volume III includes the detailed recording and reporting instructions, record formats, and codes. The Navy System, as the Army TAMMS, does not collect crew size information. It does collect Elapsed Maintenance Time (EMT), and task man-hours. The crew size, therefore, can be derived by dividing the MMH/Task by the EMT. The elapsed task time and crew size information is significant for maintainability analysis. This provides a capability to distinguish between maintainability characteristics and reliability (frequency at which the maintenance must be performed). Given that accessibility is not a problem, the mean elapsed task time and crew size describe the maintainability characteristics as opposed to the MMH/FH which also includes reliability (the frequency of the maintenance performed). Maintenance man-hours per flight hour, therefore, is not a measure of the maintainability characteristics but is more accurately an index of both the maintainability and reliability characteristics.

VAMOSC AIR

The Navy, as has the Air Force, developed a VAMOSC AIR (Visibility and Management of Support Costs) for obtaining total air vehicle operating costs data and is applicable to both Navy and Marine Corps aircraft weapons systems by type/model/series (T/M/S). There are two independent data bases in the VAMOSC AIR: The Total Support System (TSS) and the Maintenance Subsystem (MS).

Total Support System (TSS)

The TSS uses a top-down approach which develops selected costs of ownership of individual aircraft by T/M/S (for example the F-14A) to the extent that current reporting systems allow. Thirteen data sources, including seven which provide data manually on hard-copy forms, are input to the TSS. The cost data are presented in six major categories, and summarized into T/M/S total.

Maintenance Subsystem (MS)

The MS uses the bottoms-up approach which addresses direct maintenance and material costs by individual T/M/S. These costs are aggregated at the aircraft system (two digit WUC level) for summary reports. For example, summary reports provide costs displayed by the airframe, fuselage, landing gear, flight controls, etc., for the F-14A.

PURPOSE/UTILITY OF VAMOSC AIR

VAMOSC AIR was established under the guidelines of the DOD Management by Objectives Programs of FY 75 (Objective 3, Action 12) and FY 76 (Objective 9, Action 2).Each service was directed to develop and implement a cost-effective system to do the following things:

1. Identify maintenance and operations costs by weapon system

2. Demonstrate the utility of service-developed operating and support information for weapon system acquisition and logistics planning decisions using existing data sources.

3. To be more detailed for the maintenance function.

While there undoubtedly will be differences in the experience data from the Army TAMMS and Navy NAMP Systems due to operational concepts, maintenance policies, and environment, these data sources should not be discounted for their value. Action should be taken to obtain histories on aircraft currently in service as a part of the historical data base to support the acquisition process in the Air Force. Such data could be extremely useful in determining factors for adjusting for differences in environments, geographical locations, and maintenance/operational concepts and policy.

COMMERCIAL AIRCRAFT MAINTENANCE COST DATA

Direct operating cost data for commercial aircraft are available from various sources, the prime source being the Civil Aeronautics Board (CAB) Form 41 data. The CAB data base is an on-line data base available to all users of the Sharp APL System, I.P. Sharp Associates, who prepare the operating cost data summaries published periodically in Aviation Week and Space Technology on a quarterly basis.

CIVIL AERONAUTICS BOARD FORM 41

CAB Form 41 reports are submitted to the CAB in Washington, D. C. by all U. S. air carriers on a monthly and quarterly basis. The data are comprised of the balance sheet, expense, revenue and traffic statistics by type of aircraft, type of service, and airport, of over 60 carriers in considerable detail. In all, there are about 300,000 time series associated with the data base, and it occupies about 25 million bytes of disc storage.

While the commercial operating cost data cannot be directly related to Air Force operating cost data, relative comparisons can be made. Some of the problems associated with comparing operational support costs between commercial and military aircraft are presented in detail in Air Force Flight

Dynamics Laboratory (AFFDL) reports AFFDL-TR-75-64, July 1975 and AFFDL-TR-75-147, April 1976. The data does not exist, however, and should not be ignored as an existing data source.

AIRFRAME/ENGINE/AVIONICS MANUFACTURERS

Each manufacturer has developed a data base for use in performing reliability, maintainability, trade studies, and cost studies for equipment which they manufacture. Most all of them use the Air Force DO 56E and/or KO 51 data to some degree. In addition to this experience data, each manufacturer will have an engineering data file relative to design, development, test and production on the equipment the company produces. This information may or may not be filed in an automated retrieval system. These data bases are used not only in conducting conceptual design studies but are also used in performing independent research and development. Typical of such uses are: noise generation and reduction; high lift technology; development of high performance in foils; basic characterization of new materials, composites, and metals; and wind tunnel testing (to name a few).

SECTION V

HUMAN RESOURCE TECHNOLOGIES

GENERAL

Sections II, III, and IV identified and discussed source data and data systems that are available and currently in use. That is, historical data on existing weapon systems that are collected and processed by data systems, and utilized by operational, logistics, and R&D organizations of the Air Force. More prevalent and effective use of these data in the design/development of new weapon systems is needed. The remainder of this report identifies and discusses technologies developed to generate new HRD to influence the design of new weapon systems. Some of these technologies make use of the source data and data systems discussed earlier.

Section V identifies and briefly discusses research studies and current literature directed toward understanding the relationship between human resource and complex hardware systems. A common objective of past research on human resources in system design has been to develop techniques and methods to integrate activities which create demand for skilled human resources (system hardware development) and those which supply human resources (manpower, personnel, and training). In other words, these studies attempt to make it possible for human resource factors (manpower, personnel, and training) to have an influence on the hardware development process as well as to be influenced by it.

The approach used was to conduct a literature search and attempt to identify relevant works and supporting data. These works are grouped into categories and briefly discussed. The categories of works discussed are as follows:

- Human Resources as Design Constraints
- Computerized Human Resources Data for Systems Design
- Human Resource Requirement Prediction (Analytical Techniques)

- Human Resource Requirement Prediction (Simulation Techniques)
- Human Resource Design Handbooks and Related Documentation

A bibliography for each category is provided at the end of this report.

HUMAN RESOURCES AS DESIGN CONSTRAINTS

Many studies sponsored by the Department of Defense have attempted to provide a better understanding of the design process, the designer, and the relationships between design alternatives and human resource requirements. Hannah (1965) provided significant insight to the system design process relative to the manner and timing for using HRD in design. Hannah's work was tailored to the process described in AFSC Manual 375-5, which was cancelled in 1973 and replaced with AFSC 800-series documents. Other important works listed in the bibliography address human performance, human reliability, training, performance aids, maintenance task analysis, and other topics as they relate to system design.

USE AND IMPACT OF HRD IN DESIGN

During the period 1966-1971, Meister completed six important studies. The first two (1966-1967) investigated the use of human resources data by design engineers. The third one (1968) investigated the impact that human resources data generally has in terms of influencing the design of system hardware. The fourth, conducted in 1969, investigated the design engineers concept of the relationship between equipment design characteristics and the skill levels required by maintenance technicians. The fifth study, conducted in 1969, explored the influence of human resources data on system design in terms of the amount, quality and timing (availability) of the data. The sixth study, conducted in 1971, investigated the relationship between system design and the training requirements for and job performance of maintenance technicians.

The works of Meister resulted in valuable knowledge and insights about how designers perceive human resource factors, and how HRD are and can be used in system hardware design. A primary objective of his studies was to determine the feasibility of using human resource parameters to constrain the design of system equipment. That is, to establish human resource "design to" constraints in the same manner as performance "design to" constraints are used. It was found that (a) HRD is used by designers but the influence on design varies considerably; (b) the extent to which HRD influences design is a function of the quantity, quality and timing of the data available to designers; and (c) it was not feasible to establish human resource "design to" constraints, due primarily to the difficulty in accurately projecting future manpower availability.

HRD IN DESIGN TRADE-OFFS

Other research efforts have focused on the consideration of human resources in trade-off studies that are accomplished during the early stages of weapon system design. A common emphasis in these efforts was to identify and investigate decision points and trade-offs that occur in the system design/development process. A primary objective was to investigate the extent to which HRD, if properly used in design trade-offs, would potentially influence the design decisions for system equipment.

Lintz (1971) investigated the characteristics of design trade studies and the utility of HRD in these studies. He concluded that the greatest variability in trades is the choice of parameters, weighting of parameters, methods of normalizing parametric data, methods of combining parametric data, and weighting factors. He further concluded that under controlled conditions engineers will use HRD in trade-offs, and that personnel costs and quantities are given more weight than skill types, skill levels and availability of personnel. The more detailed the HRD the more weight it receives. In two other studies Lintz (1973) explored the relationships between equipment characteristics and selected human resource factors -- including training cost, training difficulty and job performance. Stepwise regression and factor analysis techniques were used to derive equations physical, and social sciences as they relate to engineering integrated systems.

to predict maintenance time, training time, training equipment costs, etc. using equipment design characteristics. Factors of length of check-out, equipment complexity, check-out difficulty, non-automatic check-out, diagnostic information, and clarity of procedures were considered. The study showed that it is possible to use this approach to generate HRD that are useful and usable in design trade studies.

In parallel with the studies of Lintz a method called Design Option Decision Tree (DODT) was being developed by Askren (1971). A summary of numerous DODT studies is provided by Askren (1976). The DODT graphically depicts the sequence of engineering decisions required as a particular subsystem design evolves. The method also depicts the key design options that may be available at each decision point. It was shown that it is possible to develop DODT's for major subsystems well in advance of the time that the actual design activity occurs. The DODTs were developed to a hardware level involving maintenance operations. Psychometric scaling methods using experienced maintenance technicians were employed to measure the sensitivity of different HRD to different design trade-off problems. It was concluded that the following human resources data were useful as criteria for consideration in design trade-offs:

1. Manpower Quantity
2. Technician Skill Level
3. Technician Job Specialty
4. Personnel Dollar Cost
5. Type and Amount of Training
6. Task Performance Time
7. Job Difficulty
8. Personnel Turnover Rate

As in previous studies it was found that the amount and timing of relevant HRD provided to the design engineers are critical. When provided quality, relevant, and timely HRD, the designer is willing to consider human resource factors in the design trade-offs.

Potter (1975) conducted a major study to further develop, implement,

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and evaluate the use of DODTs in the design process. This work again confirmed the feasibility of using DODTs as a mechanism to incorporate HRD into the design process. At present there appears to be ample evidence that DODTs can be developed and utilized to enable HRD to influence the design process. The major constraint appears to be the lack of generic (or specific) DODTs developed for the multiple subsystems involved in various types of different weapon systems. Another major constraint is the lack of quantified HRD to accompany these undeveloped DODTs.

Baran (1974) provides an excellent summary of current efforts and state of technology in the area of military personnel costing. All of the works referenced above have contributed to the development of an improved Air Force capability to predict human resource requirements, the availability of specified personnel resources, and the cost of these resources. Table 5 provides a cross-reference between the authors and areas of emphasis of the referenced work and those in the bibliography at the end of this report.

COMPUTERIZED HUMAN RESOURCES DATA FOR SYSTEM DESIGN

In the early 1960s, a pioneering work was initiated to computerize HRD for use in the system design process. This work by Reed (1963) utilized earlier work by Miller (1953), Shapero (1959), Snyder (1960) and others who developed methods for analyzing HRD in system design. Further work by Hannah (1965) was used by Whiteman (1965), Potter (1966) and Tulley (1967) to further develop computerized handling of HRD for use in system design. Reardon (1968) developed user operating guides for computerized HRD handling and utilization in the system design process.

The above works first described the generation, use and flow of human resources data in the aerospace system design and development process. Networks and flow diagrams were developed showing inputs and outputs of specific data, and the relationships to functional analysis, specifications, task analysis, R&M, personnel requirements, training and training equipment, and maintenance manuals. Oller (1968) provided vocabulary and thesaurus

Exceedance Counter Program.

Status: Operational

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TABLE 5. USE OF HRD IN SYSTEM DESIGN

Author	Areas of emphasis											
	DODT	Design trades	Hardware design process	Human performance and reliability	Training, skills, and performance aids	Designer use of HRD	Information transfer	Manpower equivalents	Manpower prediction	Task analysis	Cost	Technological change
Askren	X	X	X		X							
Baran											X	
Barnes							X					
Colwell	X											
Corsi								X				
Grinold									X			
Hannah			X									
King					X							
Lintz			X	X	X				X		X	
Meister			X	X	X	X			X			
Potter	X											X
Snyder			X									
Thomas			X	X								

techniques for a user-oriented data handling system. Later, a computerized data handling system to store, retrieve, and process HRD in a user-oriented environment was implemented through a Pilot Study Experimental System.

During the 7 year period 1968-1975 the Air Force emphasis on use of computer methods shifted to prediction of human resource requirements by means of computer simulation techniques. As a result, the Logistics Composite Model (LCOM) has emerged as one of the most successful and widely used systems for predicting human resource requirements. During the 1970s the Army LSA/LSAR programs, based upon MIL-STD-1388, also emerged as one of the most promising systems of computerized HRD for use in weapon system design.

For the past several years the AFHRL has been working on Project 1959, Advanced Systems for Human Resources Support of Weapon Systems Development. A primary objective of this project is to demonstrate the technical feasibility of methodologies geared to reduce the system ownership cost of new weapon systems. Part of Project 1959, an important study by Goclowski (1978), resulted in development of a methodology for integrating five human resource technologies. The five technologies involved are: Maintenance Manpower Modeling (MMM, also known as LCOM), Instructional System Development (ISD), Job Guide Development (JGD), System Ownership Costing (SOC), and Human Resources in Design Trade-Offs (HRDT). In the past these technologies have been individually applied at different stages and by different groups during weapon system development. The methodology developed by Goclowski is called the Coordinated Human Resources Technology (CHRT). The CHRT defines the similarities of the five technologies, integrates and coordinates their application in the system design process, and establishes a specification for a Consolidated Data Base (CDB) required to support the application of the CHRT.

The CDB is intended to support each of the five technologies, thus avoiding the need for a separate data set for each one. The CDB specification developed by Goclowski describes the input and output data, the associated sources, the processes, and the interfaces of the CDB with the CHRT. The major categories of data stored in the CDB relate to reliability, maintainability, maintenance manpower, operations manpower, training and job guides for both maintenance and operations, and system ownership cost. The CDB, as developed, is unique to each weapon system. That is, a CDB would be developed for each new weapon system under development. The CDB expands in detail with time as the weapon system acquisition cycle progresses.

To a large degree the CDB, as developed, would contain the same data included in the LSAR derived from implementing MIL-STD-1388. If current Air Force emphasis on the use of LSARs continues, every effort should be made to insure that CDB specifications are consistent with MIL-STD-1388. In this way, the LSAR could be used to support CHRT, R&M, parametric

The data were compiled for the majority of the aircraft currently in the

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estimating relationships, LCC and other program efforts. Stated another way, with consistency and compatibility between CHRT (and other human resource related technologies) and LSAR, these technologies will be more useful and usable in support of the overall weapon system program.

Table 6 provides a cross-reference between authors and areas of emphasis in the reports listed as references or in the bibliography.

TABLE 6. COMPUTERIZED HRD IN SYSTEM DESIGN

Author	Areas of Emphasis					
	System design	Task analysis	Software technique	Data input	Data thesaurus	Integration of technologies[a]
Goclowski	X	X		X		X
Hannah	X					
Miller		X				
Oller					X	
Potter			X			
Reardon			X			
Reed	X		X			
Snyder				X		
Shapero		X				
Tulley			X			
Whiteman		X	X	X		
Wilson		X	X			

[a]Maintenance manpower modeling, human resources in design trade-offs, instructional system development, job guide development, and system ownership costing.

HUMAN RESOURCE REQUIREMENTS PREDICTION (ANALYTICAL TECHNIQUES)

Throughout the past fifteen years considerable work was accomplished with analytical techniques to improve capabilities to predict human resource factors as a function of design. The development of Cost Estimating Relationship (CER) and Parametric Estimating Relationship (PER) models offer great potential for creating HRD that are particularly useful during the early phases of system design. Early application of CER/PER models would permit establishment of initial baseline cost estimates using only top level system design or performance characteristics of a proposed weapon system when little else is known about it.

DISCUSSION OF CER/PER MODELS

CER and PER models are mathematical equations, derived by statistical regression, to fit cost or other parametric data on existing similar systems to the data that reflect physical or environmental properties of the new system under development. CER and PER models can be used early in the conceptual and preliminary design stages of RDT&E to compare alternative design approaches on the basis of human resource requirements and costs.

Several CER and PER development efforts were identified in this study. The results of these studies, discussed below, are believed to be representative of the work that has been done in this area:

1. AFAPL-TR-75-88, Parts I and II, Aircraft Propulsion Subsystem Integration Cost Model, October 1975.
2. AFAL-TR-78-49, Predictive Operations and Maintenance Cost Model, August 1978.
3. AFFDL-Contract No. F33615-76-C-3056, Modular Life Cycle Cost Model for Advanced Aircraft Systems, July, 1979.
4. DOD-Contract Number DAHC-15-72-C-0052, Tactical Fighter Aircraft Maintenance Characteristics Study, Volumes I through IV, June 1974.
5. NAVY-Contract No. N00140-76-C-0025, Aircraft Maintenance Experience Design Handbook, September 1977. (Note: Condensed maintainability predictive techniques are included in the Society of Logistics Engineers International Symposium Proceedings, 22-24 August 1978).
6. IR&D Project 78D661, Lockheed-Georgia Co., Improved Cost of Ownership Estimating Techniques, March 1978.
7. CSM/SM/758-3, Evaluation of F-15 Operations and Maintenance Costs Based on Analysis of Category II Test Program Maintenance Data, August 1975.

Sample Data Collection (SDC) is in accordance with Army Regulation 750-37.

CER/PER LIMITATIONS

There are several disadvantages of CER/PER models which limit their use. First, they cannot produce reliable results for radically new system technology. Even when used on systems which are not radically different from their predecessors, there are economic trends, cost ratios, design practices, and O&S precepts which are changing continually but are not explicitly accounted for in the models. This causes the relationship between the new system and CER/PER to be less accurate, necessitating use of compensating factors which are often subjective in nature. When separate estimates are required for such system elements as built-in test equipment, tooling, spares, fuel, or pay and allowances of enlisted personnel, CER/PER models either fail or become highly detailed estimation methods which rely on much greater detailed information. In general, the finer the details that must be separately estimated, the more expensive it is to develop the needed CER/PER model. The most important disadvantage is that most published works do not include total O&S cost. Attempts to include O&S costs have generally resulted in (1) the incorporation of parameters which are difficult or impossible to cost, and (2) the massing of so much detail that many specifics of design are required, thus delaying the actual CER/PER application until later in the acquisition process. Although there are limitations in using CER/PER models, they still represent the most promising technology for considering human resource factors early in system design. Normally, a new weapon system development program will not represent a radical departure from current state of art technology. In fact, such programs strive to avoid incorporation of major step functions in advanced technology due to the associated schedule and cost risks. Moreover, when estimating relationships are developed from historical data for mature aircraft systems the regression equations inherently include technology improvements. This is due to the fact that as a weapon system is operationally used, deficiencies caused by technology, design, and/or threats are corrected over time through in-service modifications. The basic relationships (CER/PER) to as opposed to the MMH/FH which also includes reliability (the frequency of the maintenance performed). Maintenance man-hours per flight hour,

the design or performance characteristics would, therefore, automatically provide the necessary adjustment factor which can be used in the design trade-off decision.

CER/PER APPROACHES

Two of the studies identified above introduce "improvement factors" for adjusting the parametric estimates obtained. These "improvement factors" are based upon the advanced technology , or technology improvements incorporated into the new system design. At best these "improvement factors" are totally quantifiable and objectively/systematically established. Unfortunately, in the real-time world, these factors must be established by individual judgements which may vary considerably between engineers. Based upon the discussion above, the use of so-called "improvement factors" are therefore unnecessary and introduce bias (double counting) in the estimate. This conclusion was substantiated in the Lockheed IR&D Project 78D661.

Another major difference in the CER/PER approaches used is in more than one type of aircraft, or "mixing" aircraft by type. For example, some approaches combine fighter and cargo type aircraft data to establish a CER/PER while others do not. Due to the differences in mission, utilization, and environment, the design or performance characteristics cannot be comparable between different type aircraft. Neither will the magnitude of the MMH/FH or Cost/FH be the same at given levels of utilization for fighter as for bomber or cargo type aircraft.

EXAMPLE OF PER MODEL

While the effect of utilization was recognized in some of the above cases, no attempt was made to normalize the data to a specified level of utilization except in the Lockheed IR&D project. One of the problems encountered with the use of AFR 173-10 Cost Factors is that no allowances are provided for the effects of utilization, although base material cost, base level MMH/FH, and other factors are known to be influenced by utilization. Despite the inability to allow for variations in utilization, it is possible to develop realistic and accurate parametric estimating relationships using the Lockheed approach. Figures 9 through 14 illustrate the feasibility of developing realistic parametric estimating relationships for cargo aircraft using top-level system design parameters. Figure 15 portrays the specific parameters used. A total of 85 variables in the data base were used to develop the estimating relationships for the six categories identified in Figures 9 through 14.

Figure 9 presents only the independent variables selected by the regression analysis program for the six categories represented. The "X Variable Number" column in Figure 9 identifies the specific parameter numbers reflected as the X Variables in Figures 9 through 14. The "Run Number" shown in these figures identify the type aircraft i.e.; C-5A, C-7A, C-118A, C-119G, C-123B, C-124C, C-130E, VC-135B, VC-140B, and C-141A.

HUMAN RESOURCE REQUIREMENTS PREDICTION (SIMULATION TECHNIQUES)

During the past ten years the use of computer simulation has been increasingly used to predict integrated logistics support requirements for weapon systems. A bibliography showing many of the most relevant and the frequently referenced documents in this area is provided at the end of the report. Table 7 shows these reports cross-referenced to the area of emphasis in each report. Although LCOM is by far the most current and frequently used technique in the Air Force, several other important simulation techniques and models are available for predicting human resource requirements associated with weapon systems. Army and Navy models generally utilize the data bases discussed in Section IV of this report. Several of the models shown in Table 7 should be carefully investigated in follow-on research work directed toward development of a UDB. Of particular interest are skill projection, personnel/performance/crew size, and level of repair models.

LCOM MODEL

The LCOM is a system of computer models designed to apply simulation techniques to studies concerning the Air Force base level functions, e.g.,

BASE MATERIAL $/AC FY 77$
DATA SOURCE - AFR 173-10

STEP NO. 4
VARIABLE ENTERING 12
F LEVEL 203.3344
STANDARD ERROR OF Y 5.3513
MULTIPLE CORRELATION COEFFICIENT .99934
CONSTANT 11.31281

VARIABLE	COEFFICIENT	STD ERROR OF COEF
X- 3	1.21526	.03799
X- 12	-.32818	.02301
X- 13	48.00621	2.72045
X- 15	-1.75594	.07863

PREDICTED VS ACTUAL RESULTS

RUN NO.	ACTUAL	PREDICTED	DEVIATION	DEV SQUARED	PERCENT DEV
5.	385.00000	385.37471	-.37471	.14041	.097
7.	44.00000	45.51898	-1.51898	2.30730	3.337
118.	162.00000	160.52008	1.47992	2.19017	-.922
119.	31.00000	34.95380	-3.95380	15.63251	11.311
123.	34.00000	25.83993	8.16007	66.58675	-31.579
124.	52.00000	53.10522	-1.10522	1.22151	2.081
130.	57.00000	63.27676	-6.27676	39.39767	9.920
135.	73.00000	72.87130	.12870	.01656	-.177
140.	17.00000	17.47090	-.47090	.22175	2.695
141.	95.00000	91.06837	3.93163	15.45774	-4.317
TOTALS	950.00000	950.00002	-.00003	143.17236	6.644-AV DEV

PERCENTAGE OF RUN NOS. EXCEEDING DEVIATIONS OF 10 P.C. = 20.0
15 P.C. = 10.0
20 P.C. = 10.0

Figure 9. Base Material $/AC FY 77$
Data Source - AFR I73-I0

REPLENISHMENT SPARES COST - $/FH FY 77$
DATA SOURCE - AFR 173-10

STEP NO. 4
VARIABLE ENTERING 8
F LEVEL 17.4858
STANDARD ERROR OF Y 4.9739
MULTIPLE CORRELATION COEFFICIENT .99951
CONSTANT -42.25070

VARIABLE	COEFFICIENT	STD ERROR OF COEF
X- 8	1.02428	.24495
X- 33	23.68106	4.93221
X- 35	-107.90982	7.01672
X- 83	6.75248	.20635

PREDICTED VS ACTUAL RESULTS

RUN NO.	ACTUAL	PREDICTED	DEVIATION	DEV SQUARED	PERCENT DEV
5.	428.00000	428.52633	-.52633	.27703	.123
7.	25.00000	27.48694	-2.48694	6.18485	9.048
118.	74.00000	73.16037	.83963	.70498	-1.148
119.	33.00000	33.17962	-.17962	.03226	.541
123.	27.00000	24.33345	2.66655	7.11047	-10.958
124.	66.00000	68.95571	-2.95571	8.73622	4.286
130.	85.00000	92.44098	-7.44098	55.36823	8.049
135.	117.00000	111.06137	5.93863	35.26735	-5.347
140.	139.00000	137.77241	1.22759	1.50698	-.891
141.	84.00000	81.08286	2.91714	8.50973	-3.598
TOTALS	1078.00000	1078.00000	-.00004	123.69810	4.399=AV DEV

PERCENTAGE OF RUN NOS. EXCEEDING DEVIATIONS OF 10 P.C. = 10.0
15 P.C. = .0
20 P.C. = .0

Figure I0. Replenishment spares cost - $/FH FY 77$
Data source - AFR I73-I0

AGE SUPPORT - MMH/FH
DATA SOURCE - HISTORICAL DATA

STEP NO. 4
VARIABLE ENTERING 14
F LEVEL 5.8833
STANDARD ERROR OF Y .0402
MULTIPLE CORRELATION COEFFICIENT .99983
CONSTANT .50244

VARIABLE	COEFFICIENT	STD ERROR OF COEF
X- 2	.00702	.00008
X- 11	-.02450	.00309
X- 14	-.03552	.01464
X- 27	.02439	.00080

PREDICTED VS ACTUAL RESULTS

RUN NO.	ACTUAL	PREDICTED	DEVIATION	DEV SQUARED	PERCENT DEV
5.	7.68000	7.69066	-.01066	.00011	.139
7.	1.65000	1.66624	-.01624	.00026	.975
118.	3.06000	3.03568	.02432	.00059	-.801
119.	2.64000	2.66021	-.02021	.00041	.760
123.	2.41000	2.38606	.02394	.00057	-1.003
124.	3.39000	3.41626	-.02626	.00069	.769
130.	3.53000	3.52608	.00392	.00002	-.111
135.	4.17000	4.20475	-.03475	.00121	.826
140.	3.44000	3.44839	-.00839	.00007	.243
141.	4.46000	4.39567	.06433	.00414	-1.464
TOTALS	36.43000	36.43000	.00000	.00807	.709=AV DEV

PERCENTAGE OF RUN NOS. EXCEEDING DEVIATIONS OF 10 P.C. = .0
15 P.C. = .0
20 P.C. = .0

Figure II. Age support - MMH/FH
Data source - historical data

BASE LEVEL CONSUMABLES - POL - $/FH - FY 77$
DATA SOURCE - AFR 173-10

STEP NO. 4
VARIABLE ENTERING 42
F LEVEL 5.5125
STANDARD ERROR OF Y 5.8482
MULTIPLE CORRELATION COEFFICIENT .99995
CONSTANT 3.21060

VARIABLE	COEFFICIENT	STD ERROR OF COEF
X- 15	.31317	.04483
X- 23	3.79788	.87148
X- 42	-8.12911	3.46232
X- 84	6.06836	.05897

PREDICTED VS ACTUAL RESULTS

RUN NO.	ACTUAL	PREDICTED	DEVIATION	DEV SQUARED	PERCENT DEV
5.	1501.50000	1499.96526	1.53474	2.35544	-.102
7.	49.25000	55.55063	-6.30063	39.69795	11.342
118.	189.85000	188.02053	1.82947	3.34696	-.973
119.	98.50000	99.57459	-1.07459	1.15474	1.079
123.	109.75000	105.53530	4.21470	17.76373	-3.994
124.	305.25000	303.42971	1.82029	3.31347	-.600
130.	341.25000	347.06070	-5.81070	33.76418	1.674
135.	708.60000	707.88494	.71506	.51131	-.101
140.	282.05000	274.84396	7.20604	51.92695	-2.622
141.	880.20000	884.33438	-4.13438	17.09313	.468
TOTALS	4466.19989	4466.19989	.00001	170.92785	2.295=AV DEV

PERCENTAGE OF RUN NOS. EXCEEDING DEVIATIONS OF 10 P.C. = 10.0
15 P.C. = .0
20 P.C. = .0

Figure I2. Base level consumables - POL-$FH-FY 77$
Data source - AFR I73-I0

INITIAL AGE COST - $/AC
DATA SOURCE - APPLICABLE TA'S

STEP NO. 4
VARIABLE ENTERING 7
F LEVEL 16.6493
STANDARD ERROR OF Y 8.3966
MULTIPLE CORRELATION COEFFICIENT .99834
CONSTANT 66.03839

VARIABLE	COEFFICIENT	STD ERROR OF COEF
X- 3	1.00645	.05515
X- 7	-.58410	.14315
X- 32	-.22791	.01813
X- 35	111.89934	13.10413

PREDICTED VS ACTUAL RESULTS

RUN NO.	ACTUAL	PREDICTED	DEVIATION	DEV SQUARED	PERCENT DEV
5.	348.16000	350.24964	-2.08964	4.36660	.597
7.	45.71000	50.40776	-4.69776	22.06895	9.320
9.	55.86000	56.37287	-.51287	.26303	.910
97.	153.82000	150.37646	3.44354	11.85796	-2.290
119.	61.98000	58.30199	3.67801	13.52774	-6.309
123.	62.61000	60.80176	1.80824	3.26974	-2.974
130.	152.16000	167.27666	-15.11666	228.51356	9.037
1352.	153.81000	149.07196	4.73804	22.44905	-3.178
140.	46.81000	44.42280	2.38720	5.69871	-5.374
141.	300.57000	294.20806	6.36194	40.47426	-2.162
TOTALS	1381.48996	1381.48991	.00004	352.48960	4.215-AV DEV

PERCENTAGE OF RUN NOS. EXCEEDING DEVIATIONS OF 10 P.C. = .0
15 P.C. = .0
20 P.C. = .0

Figure I3. Initial age cost - $/AC
Data source - applicable TAs

BASE LEVEL REPLACEMENT COMM. SE & SE SPARES - $/FH - FY 77$
DATA SOURCE - AFR 173-10

STEP NO. 4
VARIABLE ENTERING 15
F LEVEL 2.5602
STANDARD ERROR OF Y 261.8031
MULTIPLE CORRELATION COEFFICIENT .99999
CONSTANT 183.19116

VARIABLE	COEFFICIENT	STD ERROR OF COEF
X- 4	85.28329	14.75777
X- 15	-4.68568	2.92843
X- 35	-5257.10431	533.88300
X- 83	1988.30608	59.38984

PREDICTED VS ACTUAL RESULTS

RUN NO.	ACTUAL	PREDICTED	DEVIATION	DEV SQUARED	PERCENT DEV
5.	122539.00000	122529.91309	9.08691	82.57201	-.007
7.	2328.00000	2362.13266	-34.13266	1165.03847	1.445
118.	3796.00000	3500.34808	295.65192	87410.05566	-8.446
119.	1765.00000	1774.70868	-9.70868	94.25845	.547
123.	1651.00000	1488.97171	162.02829	26253.16650	-10.882
124.	4843.00000	5001.18903	-158.18903	25023.76782	3.163
130.	6011.00000	6288.84424	-277.84424	77197.41992	4.418
135.	9439.00000	9155.64905	283.35095	80287.76172	-3.095
140.	5158.00000	5359.69501	-201.69501	40680.87598	3.763
141.	18407.00000	18475.55273	-68.55273	4699.47736	.371
TOTALS	175937.00000	175936.99805	-.00427	342894.39062	3.614-AV DEV

PERCENTAGE OF RUN NOS. EXCEEDING DEVIATIONS OF 10 P.C. = 10.0
15 P.C. = .0
20 P.C. = .0

Figure I4. Base level replacement comm. SE & SE spares - $/FH - FY 77$
Data source - AFR I73-I0

AIRCRAFT CHARACTERISTICS	TYPE AIRCRAFT												UNIT	VARIABLE NUMBER
	C-5A	C-7A	C-9	C-97	C-118A	C-119G	C-123B	C-124C	C-130E	VC-135B	VC-140B	C-141A		
WEIGHT EMPTY	320.09	18.34	61.79	78.01	56.81	40.79	31.05	101.17	71.99	105.06	21.46	134.20	LBS X 10^3	1
TAKE-OFF GROSS WEIGHT (NORM)	719.89	24.46	108.00	148.56	109.00	68.30	56.10	185.00	155.00	203.21	41.30	266.03	LBS X 10^3	2
TAKE-OFF GROSS WEIGHT (MAX)	769.00	28.50	108.00	175.00	129.40	72.70	58.80	216.40	175.00	275.50	43.75	323.10	LBS X 10^3	3
PAYLOAD	265.00	6.22	10.02	33.35	29.90	11.86	16.00	42.10	44.68	37.24	2.28	66.09	LBS X 10^3	4
WING AREA	62.00	9.12	10.01	17.69	14.63	14.47	12.23	25.06	17.46	24.33	5.43	32.28	SQ. FT.	6
WING LOADING (NORM)	115.20	26.80	107.90	84.00	74.50	47.20	45.90	73.80	88.80	83.50	76.13	82.40	LBS/SQ.FT.	8
FERRY RANGE	15.30	9.92	5.83	21.40	21.50	14.40	13.90	23.40	15.50	16.80	3.89	14.60	HOURS	11
AVERAGE CRUISE SPEED	447	128	437	209	203	158	145	189	290	451	393	422	KNOTS	12
NUMBER OF PRIMARY COMPARTMENTS	4	2	4	4	4	2	2	4	2	2	2	2	UNITY	13
FLIGHT CREW SIZE (NORM)	5	3	4	4	4	6	3	5	5	4	2	5	UNITY	14
TROOP CAPACITY (MAX)	345	31	50	96	76	62	60	200	92	126	9	154	UNITY	15
NUMBER OF GENERATORS/ALTERNATORS	7	2	3	6	5	2	2	6	5	4	4	5	UNITY	17
POWER OFF STALL SPEED	110.20	55.00	104.00	99.00	99.90	92.00	79.00	97.00	102.22	116.00	115.70	105.00	KNOTS	27
NUMBER OF ENGINES	4	2	2	4	4	2	2	4	4	4	4	4	UNITY	33
INSTRUMENT & NAVIGATION EQUIPT. WT.	0.957	0.124	0.831	0.474	0.660	0.258	0.317	0.738	0.669	0.540	0.180	1.124	LBS X 10^3	35
LANDING GEAR SYSTEM WEIGHT	37.715	1.386	4.174	7.391	4.275	4.163	2.340	11.689	5.288	10.543	1.081	10.529	LBS X 10^3	36
ENGINE INSTALLATION WEIGHT	4.793	1.544	1.095	7.610	4.758	2.879	2.509	7.406	7.827	6.398	0.824	4.580	LBS X 10^3	45
AVERAGE AIRCRAFT UNIT COST	53.51	1.23	5.53	2.28	2.31	1.12	0.95	3.04	3.14	4.64	2.81	9.70	MILLION $	83

Figure I5. Table of aircraft characteristics (AFG-2)

TABLE 7. HUMAN RESOURCE REQUIREMENTS PREDICTION (SIMULATION TECHNIQUES)

Area of Emphasis

Bibliography reference	LCOM development	LCOM applications	Monte Carlo	Army coamp	Flying hours vs. maintenance	Data base management	Boeing-goals model	Skill projection model	RAND - logistics models	Personnel models	Serendipity - PIMO	Personnel, performance, and crew size	SAMSON
1													
2			X									X	
3				X									
4					X								
5		X											
6		X											
7	X					X							
8							X						
9								X					
10	X												
11	X												
12													
13									X				
14										X			
15											X		
16												X	
17												X	
18												X	
19												X	
20	X												X
21	X												
22	X												
23	X												
24												X	

maintenance, operations, supply, etc. It permits a systematic approach to analysis of the support requirements for complete weapon systems by analyzing the impact of support resource shortages on the operational status of the weapon system. Through simulation, the best mix of resource levels that would effectively support a given weapon system flying program is determined. The model is designed to process spares on an item-by-item basis, or, where the user is more concerned with operations, to abstract the support system and treat an aggregate of spares in the form of subsytems.

LCOM Programs: LCOM is a composite of three main programs which are discussed in the following paragraphs: the pre-processing (input) program, the main (simulation) program, and the post-processor program.

The input program edits input data and provides diagnostics where inconsistencies in the data are found. It also serves as a sortie generator permitting the user to specify a flying program that will exercise the support system in the simulation model. The flying program is defined in terms of missions requiring specific types and quantities of aircraft.

The main program consists of a simulation model and two analytic models (a forecast and a decision model). The simulation model is a representation of the environment that comprises the support system. Support response to the flying schedule is in terms of system malfunctions or parts failures corresponding to those found in the reliability data; processing of the tasks which must be done for their correction; demanding the resources that are required to do the tasks; and the resulting interaction of the resource availability in the demand process. The analytic models serve to derive the requirement for resources to maintain weapon system operational effectiveness at a prescribed level through use of a marginal utility attribute. These models eliminate the requirement to make several trials with different combinations of resource levels to determine a "best mix".

The post-processor program provides time series graphs of the output statistics and plots of the tasks encountered by a particular aircraft.

These graphs provide the change in performance over the total period simulated or a comparison between two measures of performance, e.g., backorder rate and percent fill rate from supply.

Resources, including personnel, aircraft, parts, equipment, facilities, are an integral part of LCOM input requirements. During model operation, these resources may be consumed (parts), used and returned to a pool (men and equipment), or generated (repairable unit). Resource failure is discerned by a counter which is set to a value and subsequently decremented as events occur until the counter's value is zero. Sufficient latitude is provided the user so that one may describe failure criteria in the model to conform to the available data.

The LCOM simulation model is the most widely used model identified in our research and has been used extensively in the development of manpower standards at base level by the Air Force Maintenance and Supply management Engineering Team (AFMSMET) who, in 1977, was assigned the role of system caretaker. AFMSMET is responsible for the Air Force wide implementation and manpower usage of this model.

LCOM USE

Use of the LCOM simulation model in areas other than logistics was begun by the Tactical Air Command (TAC) in 1971. This introduced the manpower community to a tool that provided a significant aid in the development of Air Force aircraft maintenance manning standards. Also, LCOM simulations allowed wartime manning standards to be evaluated in a manner not possible before. Several studies are currently underway by Major Commands for manning standards (either wartime or conventional) for various aircraft, i.e.; MAC,C-5A, C-141A; AFTEC/TAC EF-111A, E-4B; USAFE, RF-4C, F-111E, F-4E; TAC, F-15; ASD, KC-135, A-10, F-16; HQPACAF, F-4E.

The input data requirements to the LCOM simulation models are both specific and detailed and are concerned with the frequency and resource requirements of maintenance tasks. This information is currently being captured through the MDCS <u>base</u> level history tapes (ABD6DA). The Common

Data Extraction Programs (CDEPs) were designed to provide this data analysis and the resultant data displays for input to LCOM. CDEP is a system of six basic programs which operate independently but interface with each other to provide a full range of detailed data output products. CDEP, like LCOM, was programmed to run on both Honeywell 600/6000 and Control Data Corporation 6000/7000 Series Computers. AFSMET Report 78-4 describes the CDEP Standard Version 1.1 that is currently available.

LCOM has tremendous potential to aid in the reduction of O&S costs if applied early in the acquisition process. The work already accomplished by the users of LCOM forms another data source which could be drawn upon for comparability analysis and LCOM input data to support the acquisition of new equipments.

HUMAN RESOURCES DESIGN HANDBOOKS AND RELATED DOCUMENTATION

There are numerous textbooks, reports, etc. that address Human Engineering (ergonomics, etc.) and provide design criteria for same. There are relatively few documents that provide specific design guidance and criteria for human resource factors (as used in this study). Reed (1975) was the first to develop a prototype design handbook for incorporating HRD into the system design process. Reed's work was evaluated by Meister (1976) and found to be quite relevant to current UDB development interests. Future UDB efforts should carefully review the above works for applicability and further development, incorporation, and utilization.

A bibliography of Department of Defense and Air Force documentation related (directly or indirectly) to a UDB development is provided at the end of this report under Human Resources Design Handbooks and Related Documentation.

SECTION VI

LIFE CYCLE COST MODELS

GENERAL

The emphasis placed on LCC by the Department of Defense has resulted in a proliferation of LCC models and applications. While it was impossible to obtain and address all of the current documentation on LCC, this section addresses several of the more important LCC models currently in use.

NEED AND USES FOR LCC

THE NEED FOR LIFE CYCLE COSTING

The LCC of a system refers to the total cost to the Government of acquisition and ownership of that system over its entire life. Generally, the cost of operating and supporting a system after it is put into use is greater than the costs of initially designing and procuring the system; yet after the system is put into use, it is difficult to significantly alter O&S costs to be incurred. LCC programs are designed to reduce system and equipment O&S costs through a greater consideration and analysis of the O&S implication of design alternatives. LCC, in order to have the greatest effect on subsequent O&S costs, must be applied as early as possible in the system acquisition process.

During the acquisition process, many management systems and technologies are in use. These include integrated logistic support, reliability, maintainability, repair level analysis, inventory management, spares provisioning, configuration control, management information systems, systems and value engineering, resources conservation, cost-effectiveness, etc. These approaches are closely inter-related, particularly in their common application to the logistic support of the operating system. Life cycle costing provides a method to balance each discipline with regard to total system cost.

USES OF LIFE CYCLE COSTING

The primary use of LCC models has been to assess the continuing viability of a system acquisition effort, i.e., whether to initiate the effort, continue into the next acquisition phase, remain in the present acquisition phase, or scrap the entire effort, is determined by a Defense Systems Acquisition Review Council (DSARC). For major programs the Request for Proposal (RFP) and subsequent program documentation requires that O&S cost estimates be provided at the end of each major program phase. These estimates are used to help determine the overall feasibility of continuing the program or project.

Acquisition strategies are differentiated by the existence of contractor competition, the stage at which multiple bidders are reduced to a single contractor, whether there is competition only at the total system level or for subsystems as well, whether each phase and/or subsystem is separately contracted for or some are combined under a common contract, etc. The LCC estimates provided by competing contractors will, in part, determine the continued participation of a given contractor. In this regard, the computation of O&S cost targets incorporated in contractual commitments in the conceptual phase may subsequently be validated and the success in meeting such targets assessed. Since contractor LCC estimates are used, in part, as competitive selection criteria, it is critically important to have and use validated LCC estimating models and techniques. Standardization is essential to avoid "apples and oranges" comparisons in both the competitive evaluation and (later) performance assessment phases.

The primary use of LCC during the acquisition process, and one which affects both DSARC decisions and contractor commitments, concerns trade-offs on alternative equipment/system design and support concepts. Cost parameters which consider LCC, established and continuously evaluated, are translated into design requirements after weighing trade-offs between system effectiveness, cost and schedule.

In order to reduce system costs and achieve a proper balance between system effectiveness and total system cost, LCC must be quantitatively applied throughout the acquisition process.

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USE OF HUMAN RESOURCES DATA IN WEAPON SYSTEM DESIGN: IDENTIFICA--ETC(U)
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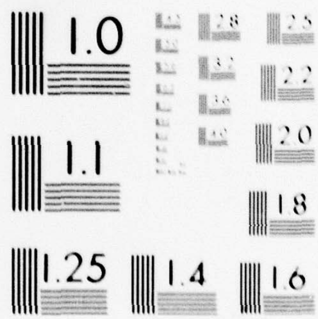

MICROCOPY RESOLUTION TEST CHART
NATIONAL BUREAU OF STANDARDS 1963-A

TYPES OF LCC MODELS

An LCC model is a series of mathematical expressions designed to address some aspect of cost during the life of a system. Strictly speaking, an LCC model is one that addresses development, production, and O&S costs. In fact, some LCC models address the entire system life cycle, while others address only part of it. Still other so-called LCC models are more narrowly defined and address specific areas, such as inventory control and level of repair.

Available LCC models can be grouped into the following six categories - cost factor, accounting, cost estimating, economic analysis, maintenance manpower planning, and special purpose.

COST FACTOR MODELS

Cost factor models typically estimate O&S cost at the weapon system level by identifying such cost elements as spares, support equipment, manpower and munitions. Estimates of each cost element are generated by multiplying key parameters of the system by a factor which is derived as a function of Air Force cost experience on similar weapon systems. The CACE model is in this category. Although cost factor models are easy to use, one serious limitation is that the cost factors are aggregate values reflecting whole system cost as opposed to subsystem cost elements. Since this type model does not explicitly break out cost in detail at the sub-system and LRU level, the approach tends not to capture the O&S cost impact of individual R&M characteristics of a new system.

ACCOUNTING MODELS

Accounting models typically compute O&S costs at relatively low levels of hardware breakdown and disassembly, e.g., the LRU level, and then total these costs. The AFLC LSC model and the AFLC O&S cost model are of this type and have historically been used by the Air Force with respect to source selection and design trade-off decisions. Accounting models have several significant limitations.

One principal weakness is the lack of a reliable and accurate set of historical data to estimate support costs to the component level on an analogous basis. This problem is due in part to the fact that the multiple data systems used by AFLC are designed for purposes other than weapon system cost accounting. Diverse sources of data yield only partial system cost visibility, and a great deal of pro-rating of common expenses applicable to several weapon systems exists. Another weakness results from the practice of managing both depot level maintenance and supply by National Stock Number (NSN), base level supply by NSN, and base level maintenance by WUC. The fact there is not a one-to-one correspondence of NSN to WUC further aggravates the data problem at the component level. These problems together with the fact that this kind of model typically requires large numbers of input data elements make model implementation a tedious exercise. Accounting models also have limited usefulness with respect to design trade-offs in that they do not relate logistic support costs directly to performance and design parameters such as material types, dimensions, speed and range. Therefore, they cannot be used early in the conceptual planning phase when trade-offs of this nature are usually made.

COST ESTIMATING RELATIONSHIP MODELS

CER models, such as those discussed in Section V, offer the greatest potential forestimating O&S costs very early in the system design process. Unlike most other models, the CER could be made available to and utilized by many individual engineers involved in initial trade-offs and design decisions. Although CERs are not LCC models in the broad sense, they provide the mechanism for integrating O&S cost considerations into the myriad of design decisions that directly affect the total LCC.

ECONOMIC ANALYSIS MODELS

Economic analysis models attempt to evaluate the economic implications of modifying or augmenting the capabilities of current weapon systems. The Research into the Economics of Design and User (REDUCE) model is the primary example of the economic analysis model. Though the model requires considerable input data, the effort is justified when a new or improved system is being considered for standardized use in the Air Force inventory.

MAINTENANCE MANPOWER PLANNING MODELS

Other computer simulation models have been developed for use in logistic support planning. These models explicitly address all aspects of logistic operations including the flying schedule, basing concept, maintenance plan, and spare and support cost. They provide a variety of output reports giving detailed statistics frequently used in trade studies and system validation tasks. Historically, these models have not been specifically oriented to LCC but rather to a much broader set of trade-off issues included under the heading of logistic support planning. Maintenance manpower planning models, in particular, have a significant impact in determining the cost of maintaining most Air Force equipments. The LCOM model is of this type and is used to estimate the maintenance manpower requirements of a weapon system under development. Further uses include evaluating tradeoffs for systems, alternative weapon systems, and systems currently in Air Force inventory on the basis of maintenance manpower requirements.

SPECIAL PURPOSE MODELS

Reliability Improvement Cost Models:

These models explicitly identify the relationship between equipment reliability and cost, i.e., more money spent on initially improving system reliability will result in subsequently greater reductions in O&S costs. In essence, the models determine the level of equipment reliability that minimizes LCC.

Level of Repair Analysis Models:

These models determine the least cost level of repair policy for new equipments as they are introduced into Air Force inventory. Various models consider LRU, shop replaceable unit, module, piece-part, and system/subsystem levels which may be either discarded at failure or repaired at either base or depot levels. System level models have an extensive requirement for input data and cost allocation difficulties where support or test equipment is used on more than one subsystem.

Inventory Management Models:

These models attempt to optimize the number of spare items required to keep a system operational. One particular model, MOD-METRIC, determines an optimal allocation of spare items for a system that can result in a considerable reduction in spares investment necessary to keep the system operational. Required inputs to MOD-METRIC includes frequency of subassembly removal, not repairable this station (NRTS) rates, etc. A well defined maintenance concept is required for these models and thus its utility in the conceptual phase of a program is limited.

SPECIFIC LCC MODELS

Many LCC models exist to consider costs in research and design actions in the acquisition process. Among the most commonly used models are the CACE model, the AFLC model, and the REDUCE model.

CACE MODEL

The CACE model was designed primarily to develop aircraft squadron annual operating cost estimates for use in LCC comparisons, cost or research analyses, or studies concerned with cost-effectiveness comparisons between weapon systems. The model uses a "building block" approach in which estimates of each cost element are generated by multiplying key parameters of the new weapon system program by a factor which is derived as a function of Air Force experience on similar weapon systems. These factors, and the "block" estimating relationships, are contained in Air Force Regulation 173-10 and are changed as new historical data becomes available. The factors used are usually developed by statistical regression. For example, the factor, replenishment spare cost/FH (RS #/FH), might be computed as a function of avionics production cost, engine production cost, airframe production cost, maximum aircraft speed and aircraft empty weight.

Disadvantages of the CACE model have been previously mentioned. The model is not designed to compute total LCC. Additional cost elements must be derived (if data can be found) in order to arrive at the RDT&E, production, initial provisioning, support equipment, training, replenishment spares, material costs, and aircraft unit cost so that a total LCC estimate may be approached.

The basic CACE model uses more than 50 data elements to arrive at its computer co. s and is the generally accepted Air Force format for preparing O&S cost estimates for submission to DSARC.

AFLC LOGISTICS SUPPORT COST MODEL

The AFLC LSC model estimates the support costs that may be incurred by adopting a particular design for a given weapon system or piece of equipment. The model is capable of (a) estimating differential logistics support costs between the proposed designs of two or more contractors during source selection; and (b) serving as a decision aid when evaluating design alternatives during prototyping prior to full-scale development. The model utilizes 95 data elements which make up 10 equations representing the following cost components: initial and replenishment LRU spares cost, on-equipment maintenance costs, off-equipment maintenance costs, inventory entry and supply management cost, support equipment cost, cost of management and technical data, facilities cost, fuel consumption cost, and cost of spare engines.

Primary Users of LSC: The primary users of the LSC model are logisticians assigned to the Integrated Logistics Support Organization which is established at each program or projects office at the AFSC Product Division. They supply necessary program-related data and government standards to contractors and advise which data elements must be furnished by contractors. Thus aerospace contractors are also a primary user of LSC. The Deputy Program Manager for Logistics should furnish the basic model computer program to contractors to insure a common base for cost estimation. Each competing contractor develops his "best estimate" of logistics support costs and his input parameters for equipment, such as MTBF. These estimates serve as one of several source selection criteria with respect to each bidder's equipment. The contractor's "best estimate" data during the conceptual phase of the acquisition process may be included in the Decision Coordinating Paper (DCP) submitted to DSARC for program approval to proceed into the validation phase. In the validation phase prototypes, mock-ups, and other system hardware may be used to revise the original estimates of O&S logistic support costs.

LSC Model Data Elements:

The LSC elements may be categorized as follows:

1. Program elements, furnished by the Government, are obtained from the scenario of the operational concept of the system (10 elements in the basic model).
2. Contractor-furnished elements are based on the contractor's design experience. While not allocated to Flight Line Unit (FLU), they contribute to overall system-level cost. (34 elements). FLU is a new term that is used for consistency with VAMOSC.
3. Contractor furnished FLU elements, based on characteristics of the design configuration, may have evolved from comparison and projection of operational experience on existing systems obtained from AFM 66-1 data. (23 elements).
4. Propulsion system elements are supplied for weapon systems with propulsion systems. The Government furnishes elements dealing with base/depot repair cycle time, resupply and build-up time, and fuel costs. The contractor supplies those elements related to engine unit costs and performance. (13 elements).
5. Government-furnished standard elements include labor rates, inventory costs, plus other cost and time standard elements (25 elements).

These five levels of data are input into a data file which is linked to the model program during execution.

LSC Model Output:

The outputs of the LSC model are displayed in several forms:

1. The total weapon system logistic support cost is broken out among the 10 equations.

2. All systems (or subsystems) are ranked in decreasing order of total cost. System identification, its total cost, and the percentage of total cost are given.

3. Total cost for a specific system is broken out among the ten equations.

4. A specified number of FLUs are ranked by cost for a specified system. The FLU identification, its total cost, and percentage of system cost are given.

5. Total cost for a specified FLU is broken out among the first seven equations.

6. A detailed SE analysis is given, in which each line of SE in a system is listed with computed fractional quantities required (base and depot) and integerized total requirements.

7. A detailed maintenance generations analysis is given showing the peak and total FLU maintenance generations for both on and off-equipment.

8. A FLU work unit code and noun-description cross-reference is provided.

REDUCE MODEL

The REDUCE model is a tool to evaluate Air Force-wide economic implication of proposed new and retrofit equipment. The REDUCE model computes the LCC implications of:

1. A retrofit program in which new equipment with different R&M characteristics will replace presently installed equipment on all or selected Air Force inventory aircraft.

2. Alternative new equipment proposals providing different equipment designs for performing additional functions on existing aircraft or specific functions on new aircraft.

3. Changes in operating and maintenance policies.

When comparing new equipment designs, the model considers estimates of RDT&E acquisition/installation, and maintenance costs. In a retrofit program, the model compares the LCC of new equipment with the support costs of the equipment it would replace. Trade-offs between a money investment in RDT&E to improve an item's R&M characteristics and consequent savings in maintenance costs over the item's operating lifetime may be readily explored using the model. The REDUCE model requires input data and is most effectively used when a new piece of equipment is being considered for use on several aircraft over a long period of time. Specifically, the model is ideally suited to evaluate the potential value of the standardization of new and low maintenance cost subsystems throughout the Air Force.

Users of REDUCE: The principal users contemplated during the model's development were analysts engaged in development planning within the Aeronautical Systems Division (ASD), although use by analysts from other divisions and commands including logisticians from AFLC were considered. The model was designed to be used during the conceptual and validation phases to estimate development, production, and O&S phase durations, costs and economic considerations.

REDUCE Simulation Models: The REDUCE model is composed of five simulation models and a data base:

1. The data base describes the scope of future operations, equipment configurations of each aircraft series, and R&M and cost factors of equipment items currently installed on these aircraft. Data in the base are changed through input to the INIT and SETUP modules.

2. The INIT module establishes a data base in a computer-storage compatible format initially and updates the established data base. INIT inputs are stored in permanent files (subject to update) from which some data will be used in every model run. This data contains R&M parameter values on U.S. Air Force equipment in the field as obtained from AFM 66-1, Maintenance Data Collection System. These values include MBTF, Mean-time Between Maintenance Actions (MTBMA), cost (labor and material) per failure, cost per maintenance action, aircraft aborts per FH, and on-equipment maintenance man-hours per failure. These values are permanent for all equipment items and aircraft series and are ordered within three cross-referenced headings: the specific equipment item; the function the item performs; and the aircraft on which the item is placed. This ordering allows a convenient outputting of a data listing in the data base.

3. The SETUP Module transforms input on proposed new equipment items into computer records which can be operated on by other modules. There is one set of data inputs for each run of the cost modules. The bulk of the SETUP inputs pertain to the R&M parameters of new equipment. It is assumed that the user can furnish estimates of these R&M parameters.

4. The ACOUT Module produces output formats with information needed to make decisions concerning item replacements. Specifically, the module processes the data checked by the INIT Module and provides the listing of data by item name, function, or aircraft name. These listings permit the user to determine what is in the data base, helps the user decide what existing items a new item is qualified to replace, and aids the user in estimating R&M parameter values for a new item by comparison with existing values.

5. The RETROFIT model evaluates the LCC effects of proposed retrofit programs. RDT&E, acquisition/installation, and

operating and maintenance costs are estimated for each new item. The duration of each phase is estimated and its cost allocated by fiscal year. A MTBF Sensitivity Analysis is conducted for new items about the target MTBF at values of 90% and 100% of the target MTBF. Determination is made of a complete set of cost outputs for each MTBF. The expected differences in operating experience between a new and the old item are calculated based on input data concerning the old item: aircraft aborts per FH, equipment aborts per FH, and on-equipment failure man-hours per failure. Also calculated are O&S savings per FH and annual O&S savings per aircraft due to a new item's use.

6. The NEW vs. NEW module is also a costing module which compares two new items on a pair-wise basis. It handles the cost estimation similarly to the RETROFIT Module. Whereas the RETROFIT Module determines development and acquisition costs for just one new item, the NEW vs. NEW module executes a new item program schedule for each new item. Similarly, rather than outputting a "savings" between old and new, the model outputs the difference in LCC between new items.

<u>Historical Data Used by REDUCE</u>: As in the LSC model, the REDUCE Model uses historical data in estimating R&M parameter values for new equipment by adapting the parameter values of an existing similar equipment design to obtain a first order estimate, where the data are available. There are several data sources from which data is obtained for the REDUCE model. In general, they provide excellent sources for work with any LCC model.

1. Force structure data can be obtained from USAF planning documents containing official USAF programmed and objective force structures for future years. Data for new aircraft may be derived from ASD studies on a new aircraft.

2. The primary source of aircraft-item data for existing programmed force elements can be found in AFM 66-1.

3. Established REDUCE model data bases containing data on existing equipment items which are similar in design to a new item being considered may be used.

4. Armed Forces reports documenting cost analyses are available.

5. Studies may be used on the relationship between testing and associated product improvement efforts included in a new item's RDT&E program and one item's MTBF.

6. Estimates furnished by contractors who are proposing a new item for consideration, or estimates (engineering and cost analyses) on a specific new item performed by AFSC personnel may be used.

MODEL INPUT DATA AND COSTING COMPARISONS

In order to more fully understand the differing data requirements of similar LCC models, a comparison of three accounting models (LSC, O&S, SOC) and one cost factor model (CACE) is made in Tables 8 and 9.

The AFLC LSC model has been previously discussed. The AFLC O&S cost model also estimates support cost as a function of logistics parameters. However, the LSC model breaks down cost to the FLU level for support equipment whereas the O&S cost model does not. The O&S cost model was used for full scale development source selection on the A-10 program.

The System Ownership Cost (SOC) model is a series of weapon system dependent cost equations which can provide a SOC estimate to the subsystem level. The equations were derived partially by modifying existing model equations and partially by generating entirely new equations. In particular, AFHRL work on the Digital Avionics Information System Life Cycle Cost Study and the existing AFLC LSC Model User's Handbook were incorporated.

Table 8 shows the costing equations included in the LSC, O&S, SOC, and CACE models. As would be expected the SOC model developed by AFHRL is heavily oriented to human resource factors and is more narrow in scope than the others. The SOC and LSC model equations are very similar, however, with both addressing factors in much less scope and detail than the O&S and CACE models. The O&S model is similar to the CACE model, but as expected the CACE model provides for macro costing in the broadest scope.

Table 9 compares the data elements contained in three cost equations common to all four models (LSC, O&S, SOC and CACE). These three cost equations are Personnel Training Costs, Cost of Spares, and Cost of Fuel Consumption. The "data elements" columns list the various data elements included in each equation. Each equation is <u>underlined</u> and data elements appear below it. The matrix shows for each model (by equation) the data elements that are included. Where data elements are common but differences in form and/or content exist, a notation is provided. A similar comparison could be made for each of the equations in all four LCC models.

It is obvious from Tables 8 and 9 that there is close similarity between the LSC and SOC models. This fact was pointed out by Goclowski (1979) in developing the SOC model. It must be determined whether or not a separate cost model is needed for the UDB of human resources information.

TABLE 8. LIFE CYCLE COST MODEL EQUATIONS

<u>AFLC LSC model</u>

I. Cost of FLU spares
2. On-equipment maintenance
3. Off-equipment maintenance
4. Inventory management cost
5. Cost of support equipment
6. Cost of personnel training
7. Cost of mgt. and technical data
8. Cost of facilities
9. Cost of fuel consumption
I0. Cost of spare engines

<u>System ownership cost model</u>

I. Cost of LRU spares
2. Cost of on-and off-equipment maintenance
3. Cost of inventory management
4. Annual cost of support equipment
5. Cost of aircrew
6. Cost of personnel training
7. Cost of job guides
8. Cost of technical record data
9. Cost of facilities
I0. Cost of fuel
II. Cost of depot repair

<u>AFLC O&S cost model</u>

I. Operating personnel costs
2. Consumables costs
3. Training costs
   a. Initial & replacement
   b. Recurring
4. Maintenance costs
   a. Organizational
   b. Intermediate
      (I) Repair
      (2) Replenishment
      (3) Pipeline
      (4) Transportation
   c. Depot (system level)
   d. Depot (sub-system or component level)
      (I) Repair
      (2) Replenishment
      (3) Pipeline
      (4) Transportation
5. [a]Facilities
6. Initial gov't furnished material & services
7. Support & test equipment
8. Data costs
9. Salvage & disposal
I0. Initial & replacement transportations
II. Supply mgt.
I2. Development & test

[a]No eqns were provided in sources for costs (5) through (I2); however, these cost elements should be included in model formulation.

<u>CACE</u>

I. Recurring investment & misc. logistics
   a. Common AGE (incl. spares)
   b. Aviation fuel
   c. Maintenance - aircraft
      (I) Base level (material only)
      (2) Depot level
   d. Modification, class IV (incl. spares)
   e. Munitions, training
   f. Replenishment spares
   g. Vehicular equipment
2. Pay and allowances
   a. Military
   b. Civilians
3. Primary program element manpower (Officer, Airman)
4. Base operations/real property maintenance (Officer, Airman)
5. Medical dispensary (Officer, Airman)
6. Permanent change of station (Officer, Airman)
7. Pipeline costs
   a. Acquisition
      (I) Pilot
      (2) Nonpilot Crew (Officer)
      (3) Nonaircrew (Officer)
      (4) Airmen
   b. Training
      (I) Pilot
      (2) Aircrew (Officer)
      (3) Nonaircrew (Officer)
      (4) Airmen (base-level aircraft maintenance)

TABLE 9. COMPARISON OF DATA ELEMENTS IN LCC MODELS

DATA ELEMENTS	AFLC LSC	AFLC O&S	SOC	CACE
<u>Personnel training costs</u>	X	X	X	X
System operating life (yrs)	X		X	
Annual personnel turnover rate (Base Pers)	X		X	[6]X
Cost of Peculiar Training per man (Base) incl/instructions and training materials	X	[4]X	[3]X	
Direct productive MH: "touch time," transportation and set-up time	X		X	
# Different FLU in system	X		[1]X	[5]X
Expected total force FH	X		X	
# Like FLUs	X		[1]X	
Ratio: OpH/FH for each FLU	X			
MTBF in OpH for FLU	X			
MH used to prepare access for FLU repair	X			
Avg. engine OpH between removal of whole engine	X			
Avg MH to remove/replace whole engine	X			
Annual turnover rate/depot personnel	X		X	
Cost of peculiar tng - depot personnel	X	[4]X	[3]X	
Direct productive MH - depot	X			
Fraction removed FLUs expected to be repaired at depot	X			
Avg MH to depot maint on FLU	X		X	
Cost of peculiar tng equipment for system	X		X	
Fraction FLU failures repaired in place w/out removal	X		[1]X	

DATA ELEMENTS	LSC	O&S	SOC	CACE
<u>Cost of spares</u>	X[1]	X[2]	X[3]	X[4]
# of repair locations (Operating Bases)	X		X	
# Spares required for each base to fill base repair pipeline	X		X	X[5]
Unit cost of spare at initial provisioning	X		X	
Peak force FH	X			
# Like spares in parent system	X		X	
Ratio of OpH to FH for a spare	X	X	X	
Fraction of spare failures to be repaired on place w/out removal	X	X		
Fraction of removed spares returned to depot for repair	X	X		
Weighted avg. depot repair cycle time	X			
Expected total force FH	X	X		X
Fraction removed spares to be condemned at base	X	X	X	
Mean time between failure	X			
Op service life of Wpn system			X	
# Different spares in system		X	X	
Expected force FH in year k		X		
Replenishment spares factor cost/FH				X
AGE factor				X
Flyaway costs 'Now' $/aircraft				X
MOD factor				X

TABLE 9. (Concluded)
COMPARISON OF DATA ELEMENTS IN LCC MODELS

DATA ELEMENTS	AFLC LSC	AFLC O&S	SOC	CACE
Personnel training costs				
Avg MH to repair FLU in place	X			
Avg MH to perform shop bench check on FLU prior to repair/condemn	X			
Fraction FLUs to be repaired at base	X		[2]X	
Avg MH to perform base maint on FLU	X			
FH interval between periodic or phased inspections on system	X			
Avg MH to perform inspection	X			
# Engines on aircraft	X			
Maintenance MH per maintenance action			X	
Up-date trng costs		X		
# of personnel who require up-date trng but not init trng		X		
Recurring training costs		X		
Crew ratio (Pilot, Officer Aircrew)				X
UPT Training factor (Officer)				X
Trng factor (excl UPT)(Officer)				X
Trng factor (Airman)				X
Total my/aircraft/year for Pilots, other Officer, base-maint Airmen				X
PPE AMY & BOS/RPM AMY 7				X

I. # LRUs in mth subsystem
2. # SRUs in ith LRU
3. Non-recurring training costs
4. Induction & initial trng costs
5. Unit equipment/squadron
6. Sub-divided into Officer, Airman
7. Primary program element(Officer & Airman) + Base Operation/ Real Property Maint. and medical dispensary (Officer & Airman)

DATA ELEMENTS	LSC	O&S	SOC	CACE
Cost of fuel consumption	X[6]	X[8]	X	X
Expected total force FH	X	X	X	X
# Engines per aircraft	X		X	
Fuel consumption rate of one engine per FH	X	X[7]	X	
Fuel cost per unit	X	X	X	
Discount factor over time		X		
Unit equipment/squadron				X
Fuel factor cost/FH				X

I. Cost of FLU spares
2. Initial spares, replenishment spares, and repair costs are imbedded in maintenance costs equations.
3. Cost of LRU spares
4. Replenishment spares,Class IV Modification(incl. initial spares)
5. # Unit equipment/squadron
6. LCC of fuel for systems w/propulsion systems
7. Total consumption
8. Fuel consumption is expressed in a gen.consumables eqn.

ABBREVIATIONS

ADCOM	-	Air Defense Command
ADP	-	Automated Data Processing
ADPS	-	Advanced Personnel Data System
AFAFC	-	Air Force Accounting and Finance
AFAL	-	Air Force Avionics Laboratory
AFALD	-	Air Force Acquisition Logistics Division
AFAPL	-	Air Force Aerospace Propulsion Laboratory
AFCS	-	Air Force Communication Service
AFFDL	-	Air Force Flight Dynamics Laboratory
AFG	-	Air Force Guide
AFHRL	-	Air Force Human Resources Laboratory
AFLC	-	Air Force Logistics Command
AFM	-	Air Force Manual
AFR	-	Air Force Regulation
AFRES	-	Air Force Reserve
AFSC	-	Air Force Systems Command
AFTEC	-	Air Force Test & Evaluation Center
AFTO	-	Air Force Technical Order
AGE	-	Aerospace Ground Equipment (now called Support Equipment)
AGMC	-	Aerospace Guidance (Systems) Maintenance Center
ALC	-	Air Logistics Center
AMC	-	Army Material Command
AMMIS	-	Aerospace Maintenance Manpower Information Service
ANG	-	Air National Guard

ASIP	-	Aircraft Structural Integrity Program
ASD	-	Aeronautical Systems Division
ATC	-	Air Training Command
ATE	-	Automatic Test Equipment
AUTODIN	-	Automatic Data Transmission System (AUTODIN = Data Transmission AUTOVON = Voice Transmission)
AVISURS	-	Aerospace Vehicle Inventory, Status and Utilization Reporting System
AVGAS	-	Aviation Gasoline
CAB	-	Civil Aeronautics Board
CACE	-	Cost Analysis, Cost Estimating
CAMMIS	-	Command Aircraft Maintenance Manpower Information System
CAMMS	-	Command Maintenance Manpower System
CDB	-	Consolidated Data Base
CDEP	-	Common Data Extraction Program
CDTS	-	Computer Directed Training System
CEM	-	Communications, Electronics, Meteorological
CER	-	Cost Estimating Relationship
CHRT	-	Coordinated Human Resource Technology
COCESS	-	Contractor-Operated Civil Engineer Supply Stores
COPARS	-	Contractor-Operated Parts Stores
CREATE	-	Time Sharing Computer Program to Support Engineering, Logistics & Students
DARCOM	-	U.S. Army Material Development & Readiness Command
DID	-	Data Item Description

DOD	-	Department of Defense
DODT	-	Design Option Decision Tree
DSARC	-	Defense Systems Acquisition Review Council
DSD	-	Data System Designator
EAD	-	End Article Designator
ECOM	-	Electronics/Communication
EMT	-	Elapsed Maintenance Time
ETA	-	Exception Time Accounting(System)
FH	-	Flying Hour
FLU	-	Flight Line Unit
FMC	-	Fully Mission Capable
FSC	-	Federal Stock Code
FYDP	-	Five Year Defense
GFM	-	Government Furnished Material
GPS	-	Ground Processing Segment
How Mal	-	How Malfunctioned
HRD	-	Human Resources Data
HRDT	-	Human Resources in Design Trade-off
ICBM	-	Intercontinental Ballistic Missile
I.D. No.	-	Identification Number
ILDF	-	Integrated Logistics Data Files
ILS	-	Integrated Logistics Support
INV	-	Inventory
IR&D	-	Independent Research & Development
ISD	-	Instructional System Development

JCN	-	Job Control Number
JETD	-	Joint Electronics Type Designator
JGD	-	Job Guide Development
LCC	-	Life Cycle Cost
LCOM	-	Logistics Composite Model
LRU	-	Line Replacement Unit
LSA	-	Logistic Support Analysis
LSAR	-	Logistic Support Analysis Record
LSC	-	Logistic Support Cost
LTF	-	Lead the Force
M	-	Maintainability
MAC	-	Military Airlift Command
MADARS	-	Maintenance Data Analysis and Recording System
MAJCOM	-	Major Command
MCS	-	Maintenance Cost System
MDCS	-	Maintenance Data Collection System
MDS	-	Mission Design Series
MESL	-	Mission Essential Subsystem List
MFG	-	Manufacturer
MICAP	-	Mission Capability
MIICS	-	Master Item Identification Control System
MILAP	-	Maintenance Information Logically Analyzed & Presented
MIL-STD	-	Military Standard
MIP	-	Material Improvement Projects

MMH	-	Maintenance Manhours
MMH/FH	-	Maintenance Manhours Per Flight Hour
MMICS	-	Maintenance Management Information Control System
MMM	-	Maintenance Manpower Modeling
MOD	-	Modification
MTBF	-	Mean Time Between Failures
MTBMA	-	Mean Time Between Maintenance Actions
NAMP	-	Naval Aviation Maintenance Program
NMC	-	Not Mission Capable
NRTS	-	Not Repairable This Station
NSN	-	National Stock Number
OCALC	-	Oklahoma City Air Logistics Center
OFP	-	Operational Flight Program
OMB	-	Office of Management and Budget
OOALC	-	Ogden Air Logistics Center
OPR	-	Office of Primary Responsibility
O&S	-	Operations & Support
OSCR	-	Operations & Support Cost Report
PATTERN	-	Planning Assistance Through Technical Evaluation of Relevance Numbers
PCN	-	Product Control Number
PEC	-	Program Element Code
PER	-	Parametric Estimating Relationships
PLSS	-	Precision Location and Strike System
PMC	-	Partial Mission Capable

PME	-	Precision Measuring Equipment
POL	-	Petroleum, Oil and Lubricant
POMO	-	Production Oriented Maintenance Organization
PROFILE	-	Programmed Functional Indices for Laboratory Evaluation
QUEST	-	Quantitative Utility Estimates for Science and Technology
R	-	Reliability
R&D	-	Research and Development
RCS	-	Reports Control Symbol
REDUCE	-	Research Into the Economics of Design and User
RFP	-	Request for Proposal
RIW	-	Reliability Improvement Warranty
R&M	-	Reliability and Maintainability
SAALC	-	San Antonio Air Logistics Center
SAMSO	-	Space and Missile Systems Office
SBSS	-	Standard Base Supply System
SDC	-	Sample Data Collection
SE	-	Support Equipment
SEDS	-	Systems Effectiveness Data System
Seq. No.	-	Sequence Number
SMALC	-	Sacramento Air Logistics Center
SOC	-	System Ownership Costing
SPO	-	Systems Program Office
SRAM	-	Short Range Attack Missile
SRD	-	Standard Reporting Designator
SRU	-	Shop Replaceable Unit

TAC	-	Tactical Air Command
TAMMS	-	The Army Maintenance Management System
TM	-	Technical Manual
T/M/S	-	Type/Model/Series
T.O.	-	Technical Order
TCTO	-	Time Compliance Technical Order
TRAMIS	-	Technical Training Management Information System
TRI-TAC	-	Terminal Radio Set, TRC-170
TSS	-	Total Support System
UDB	-	Unified Data Base
USAF	-	United States Air Force
USAFSS	-	United States Air Force Security Service
VAMOSC	-	Visibility & Management of Operating & Support Costs
WBS	-	Workload Breakdown Structure
Wh Dis	-	When Discovered
WUC	-	Work Unit Code
Yr	-	Year

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